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ABSTRACT

Forty-two volunteer subjects, mostly young adults, participated in developing a methodology for studying cognitive processes and cerebral lateral functions in relation to individual cognitive styles and age. Four test batteries were developed and refined in this study: the adult cognitive, the adult electroencephalogram (EEG), the children's cognitive, and the children's EEG. Subjects were given group cognitive tests four weeks prior to EEG testing and individual cognitive tests at the time of EEG testing. A resting EEG was obtained for ten minutes before the laterality cognitive testing. Start and stop times for each cognitive task and for the rest period were logged, and activation of right and left brain hemispheres was plotted. Input data were filtered with bandpass filters in order to evaluate relative EEG activation as indicated by the power and bandwidth of an activated hemisphere. For most subjects, there was no consistent use of one or another hemisphere for any task; in fact, there were occasional shifts of activation from one hemisphere to the other. A uniquely different subject was a 13-year-old girl who had outgrown a mild dyslexia; the usual oscillation of dominance activity during task performance was lacking, and there was a failure to shift hemisphere-dominance in relation to task. Several of the tests are appended. (Author/MV)

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FINAL REPORT

An Investigation of Cerebral Lateral Functioning and the EEG

Prepared for
Hewitt Research Foundation
Under Research Grant #50079-G-73-02-1
from the U.S. Office of Economic Opportunity
and monitored by the
National Institute of Child Health and Human Development

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July, 1975

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The purpose of this project was to investigate a number of significant variables linking brain function and cognitive processes, and to develop a valid, reliable, and conceptually rational methodology for this investigation . . . suitable for use with subjects of various ages from childhood to adulthood.

The overriding assumption guiding this project is that there are non-specific cerebral functions which roughly localize differentially in left and right hemispheres. These functions relate to the efficiency with which cognitive tasks are performed in each hemisphere and the "congeniality" or "pre-structuring" of each hemisphere for certain cognitive tasks. This assumption originates from the work of Sperry, Bogen, Levy, and others dealing with humans who had undergone surgical splitting of the corpus callosum and optic chiasm (for tumor, etc.). Briefly, these investigators demonstrated that for right-handed individuals, the left hemisphere was more efficient and played a major role in dealing with tasks having to do with logic, analytic ability, verbal activity, and arithmetic. The right hemisphere was more heavily utilized in relation to three dimensional space perception, Gestalt perception, intuition, and musical tone discrimination.

These findings and their related concepts were advanced and applied by Galin, who demonstrated the utility of the electroencephalogram (EEG) as an indicator of lateralized cerebral activation during the performance of cognitive tasks selected for their "demand" on left or right cerebrum (e.g. verbal tasks versus

spatial tasks).

We hypothesized an individual's cognitive style would be a significant variable influencing some aspects of the lateralized cerebral response to a given cognitive task. Cognitive style refers to the patterns of cognitive modes most congenial to an individual. It more specifically refers to individually characteristic ways of organizing the data of perceptual experience. Thus, for the "cognitive style" or "cognitive control" of field dependence versus field independence, the field dependent individual prefers to see (and shows greater facility) large organized groupings or patterns and tends to ignore the particulate items making up a pattern. The field independent individual tends to focus on the particulate details within an organized pattern.

Imbricated consequences of this hypothesis were that utilization of a certain cognitive style correlates with cerebral hemisphere used in task solution. These nesting hypotheses point to a modification of the operant aspect of the leading hypothetical framework. Derived from this, we hypothesized as follows:

1. There are lateralized cerebral EEG responses concomitant with the performance of selected cognitive tasks.
2. These lateralized EEG responses would be influenced by or would interact with the individual's cognitive style.
3. There are individual differences in cerebral lateral responses during cognitive effort.
4. These individual differences would relate to cognitive style, age, and sex.

The specific purpose of this investigation was to develop a proper methodology for studying lateralized cerebral changes during the performance of cognitive tasks, to search for individual differences, and to relate these to cognitive style and to age. Sex differences may play a part in biasing lateralized EEG responses (e.g. it has been shown by Macobee that girls develop verbal skills earlier than boys, and boys develop three dimensional spatial perception skills earlier than girls). We decided to control for but not investigate this variable at this time.

The future aim of the study was and is to develop and then apply these methodologies and findings to similar studies of development of this coupling between cognition and cerebral lateral functions in children. Previous work in this laboratory (Metcalf, 1972) has shown that lateralization of the resting awake EEG is not achieved before age four or five years and not unequivocally established for most children before eight or nine years. We later show that there are specific EEG changes (power spectral density shifts in the alpha band) associated with the process and solution of cognitive tasks by children. Thus, we are already aware of probable important developmental factors related to EEG lateralization and related to EEG changes during cognitive activity.

Thus, the long-range goal of the work herein reported is the study of the development, the ontogenesis of these functions in normal children and in children with cognitive (e.g. learning) difficulties, in children with identified cerebral pathology, and in children of various ages. At some time in the future, it would be important to apply these findings to studies of "culturally deprived" groups where learning styles are apparently different from those found among normal middle class children.

Evolving out of such findings would come more accurate and detailed knowledge about one aspect of the brain-behavior relationship. Those familiar with EEG work and with the use of cognitive testing in children will understand the difficulties involved, not only at the conceptual level, but especially at the methodological level. We chose therefore to focus our initial activities on work with young adults. Subsequent to the refinement of technology and methodology we would gradually apply these tools to the study of children.

METHODOLOGY

A. General

Three methodological and technological areas were explored and refined before the study-proper could be implemented.

1. Cognitive Style Battery

a. Adult Tests: Tests were developed (see Index) utilizing primarily established and standardized material, which were reliable and valid for ascertaining cognitive style in adults. Where possible, they were suitable for group administration.

b. Children's Tests: The more difficult task of developing and learning to administer tasks which tested functions similar to the adult tests but applicable to children was next confronted.

c. After requisite experience with potentially useful tests, final-form test batteries were constructed, and experience obtained in their standard administration and scoring.

2. Laterality Battery

a. An adult and a child's battery of tests was devised.

b. Each test item was selected in terms of its putative ability to elicit either left cerebral or right cerebral activation (based on split brain data of Sperry, Bogen et al.).

c. Pilot studies were done to confirm the above selection and to design test items of our own which might be particularly useful or suitable.

d. Each laterality battery was designed to contain a sampling of the following types of items:

(1) Items which would be strong activators of the left hemisphere EEG.

(2) Items which are strong right hemisphere activators.

(3) Items which were variable between individuals. Such "ambiguous" items were important as a source of information about individual differences; i.e. a subject with a strong predilection for right hemisphere utilization might perform verbal tasks with right hemisphere activation via a kind of "free association" process. On the other hand, a "left hemisphere-prone" subject might perform such a task in a precise, systematic, "file-searching" way. Ambiguous items would also be used to evaluate the influence of age and development on lateral choice during cognitive activity.

3. EEG Recording

An important requirement for the battery is that it could be administered

simultaneously with the EEG recording without the production of excessive eye movement, muscle activity, and other sources of EEG artifact which would tend to interfere with subsequent EEG analysis. We did not entirely succeed in this endeavor.

a. Methods of recording the EEG, although available and well-tested, had to be adapted to be used with subjects who might be performing and moving. Electrode application had to be impeccable, electrode location precisely measured, and the optimal location of electrodes for demonstrating lateral cerebral activation had to be determined. A good deal of time and effort went into this refinement of methodology. Certain conclusions were reached which we were unable to use, e.g. the advisability of using biotelemetry for the purpose of obtaining low artifact EEG, and for the purpose of freeing the subjects from "hard wire" attachment to the EEG apparatus. Other conclusions were adopted after considerable pilot experience, e.g. earphones, though offering more precise administration of auditory stimuli and screening-out ambient noise, etc., tended to interfere with the integrity of the EEG recording.

4. Data Analysis

a. After considerable loss in time using PDP-12 software of several different varieties and attempting to circumvent or alter their built-in deficiencies relative to our work, we were able to obtain considerable help from Dr. T. Joe Willey and his programmer, Ms. F. Roos. They gave generously with time, effort, and on-site consultation. Their software produced power spectral density plots of the EEG which were reliable and rapid. The mass of data accumulated demanded a rapid, efficient system.

b. It became evident that mathematical analysis of our spectral displays was necessary. To this end, with the funding of this grant, additional PDP-12 hardware was obtained (Disc package and Dataphone) so that we could communicate with the University of Colorado Scientific Computing Center's large, general purpose computer. Unfortunately, program writing (for which we were not funded) has lagged considerably and we have been unable to finalize and implement this necessary step. This work is continuing with other, limited funds, and these data will be numerically analyzed and analyzed using auto-regression techniques subsequent to the termination of this project's support.

B. Specific

Volunteer subjects were given individual and group cognitive tests. Group tests were administered approximately four weeks prior to EEG testing. Individual subjects were then scheduled for EEG recording. Individual tests were administered at the time of the EEG recording.

At the time of EEG recording, eight gold cup electrodes were attached to left and right occipital, parietal, mid-temporal, and high central scalp locations (International locations O1, O2, P3, P4, T3, T4, C3, C4). Scalp electrode resistances were less than 5000 ohms. Montages recorded were as follows: P3--O1; P4--O2; C3--T3; C4--T4. These montages were chosen after exhaustive experimentation searching for electrode arrangements which would most optimally reveal lateralized EEG responses. EEG's were recorded on multi-channel strip-chart and on multi-track FM magnetic tape simultaneously. An IRIG-B timecode was simultaneously imposed on the strip-chart recording and on magnetic tape. To control for amplifier distortion at EEG machine

and at tape recorder, a sinusoidal, 10 Hz signal from a signal generator was imposed on the entire recording system (from EEG input, through EEG amplifiers, through tape input through tape output). This signal was monitored via oscilloscope in order to insure that no asymmetries were introduced by individual items in the recording and playback system. This oscilloscope monitoring was then repeated with the patient attached. Amplifiers were adjusted to furnish the tape recorder with optimum input signal (neither "over-driven" nor "under-driven"). Amplifiers were then rechecked and if necessary rebalanced for "across the board" equalization. Recording could then commence.

A resting EEG was obtained for 10 minutes prior to cognitive testing. Over-breathing and making a "tiger face" were utilized to help subjects relax facial and scalp musculature. During the administration of the laterality-cognitive testing, written observations were recorded on the running strip-chart at frequent intervals. Subjects were queried regarding their individual methods of task-confrontation (e.g. did they "visualize" during word association tasks, etc.). Following each subject's testing, the strip-chart EEG (about two hours of testing) was logged in relation to task and timecode. Total analog FM tape was processed on the PDP-12 computer. The digitized data was handled so that each cognitive task was entirely digitized; start and stop times for each task and rest period were logged. A plot of stacked spectra for left and right hemisphere EEG (power spectral density. . .p.s.d.) was then produced. Input data were filtered at three and 15 Hz with bandpass filters so that input data fulfilled the requirements of the PDP-12, p.s.d. algorithm to prevent aliasing. Sample serial stacked spectral plots are shown here and in the appendix. Four-second EEG epochs are serially and continually plotted for each task. The bandwidth and power within the general alpha range (7-13 Hz) are then evaluated. Criteria for relative EEG activation are less power and narrower bandwidth for the activated hemisphere. These criteria are now open to some question (see Discussion), and cannot be precisely understood without autoregression analysis or some other more precise form of numerical analysis of these p.s.d. data.

TEST BATTERIES

Four test batteries were utilized as follows: (1) Adult Cognitive Battery; (2) Adult EEG-Laterality-Cognitive Battery; (3) Child Cognitive Battery; (4) Child EEG-Laterality-Cognitive Battery.

A. Adult Cognitive Battery

1. Physiognomic Cue Test
2. Mental Block Rotations
3. Ravens Progressive Matrices
4. Stroop Test
5. Contrast Reactivity Test
6. Schematizing Test of Leveling-Sharpening
7. Rod and Frame
8. Witkin's Embedded Figures
9. Handedness Questionnaire
10. Color Blindness Test

B. Adult EEG Battery

1. Serial 7's - silent, without visualization
2. Beethoven
3. Concrete Word Association - with visualization
4. Mental Block Rotations
5. Mental Trip
6. Serial 7's - whispered, without visualization
7. Cat Stephens (modern music)
8. Abstract Word Association
9. Anagrams
10. Serial 7's - silent, with visualization
11. Bartok
12. Raven's Progressive Matrices

C. Children's Cognitive Battery

1. Physiognomic Cue Test
2. Raven's Colored Progressive Matrices for Children
3. Fruit - Distraction Test
4. Contrast Reactivity Test
5. Schematizing Test of Leveling-Sharpening
6. Leveling-Sharpening House Test
7. Rod and Frame Test
8. Children's Embedded Figures Test (colored)
9. Handedness Questionnaire
10. Color Blindness Test

D. Children's EEG Battery

1. Serial 7's - silent, without visualization (either adding or subtracting, depending on the child's arithmetic skills)
2. Listening to Music
3. Word Beginnings and Endings Test
4. Card Rotation Test
5. Mental Trip
6. Serial 7's - whispered, without visualization
7. Things Category Test
8. Anagrams
9. Raven's Colored Progressive Matrices for Children
10. Children's Embedded Figures Test (colored)
11. Surface Development Test
12. Serial 7's - silent, with visualization

The EEG battery contains putative left hemisphere items (mental arithmetic, concrete word association, and anagrams), and presumed right hemisphere items (music listening, mental block rotations, mental trip--"take an imaginary trip in your mind's eye"), abstract word association. The Raven's Progressive Matrices was viewed as an ambiguous task, as was arithmetic performed with mental "visualization". The Raven's could be performed either through a rapid recognition "intuitive" process or a careful, logical analytic process.

RESULTS

Pilot analysis was done on 18 subjects. These data could not be used for a variety of reasons. Often, we were experimenting with and developing new methods. Equipment malfunction (an inexpensive tape recorder obtained for this project proved to be too unreliable and produced unexpected quantities of unusable data). Occasional subjects were unable to consistently perform (one fell asleep during the testing). Intermittent malfunction of the PDP-12 computer produced considerable lost time. A change in research technicians during the course of the project also slowed progress. Despite these and other interferences, 12 subjects were completely tested. Based on this funding source as start-up "seed money", we are able to continue this work during this calendar year in anticipation of future major funding to further advance this work. Our principle and most significant finding among both pilot subjects and complete subjects (N=30) is that most of our normal subjects do not show consistent use of one or another hemisphere for any task. Most subjects (including a well-known, extremely creative and productive octogenerian who volunteered for this project) showed power spectral density displays which oscillated between left and right hemisphere activation in terms of bandwidth and relative power in one hemisphere as compared with the other during the performance of the assigned cognitive tasks. The expected monotonic relationship of cognitive task to hemisphere activation does not usually occur. An occasional subject did, in fact, demonstrate strong shifts of activation from one to the other hemisphere in relation cognitive task.

Lastly, of great interest, is the one child we were able to test, a 13 year old girl who had "outgrown" a mild "dyslexia". Her findings were uniquely different. This subject showed a failure to shift hemisphere-dominance in relation to task and also failed to show "more normal" oscillation of dominance activity during task performance.

DISCUSSION

These findings are in partial but important disagreement with those of Galin who suggests a fairly regular relationship between task and which hemisphere is activated. This may in part be due to differences in our methods. We chose to analyze our data in four-second serial epochs; his data are analyzed in larger blocks, reflectin a more global, ensemble averaging of data. There may be subject differences of which we are unaware. We are struck by the unique finding of one individual, a child with a minor learning difficulty, who shows no interhemisphere shifting response under any circumstances. We are not yet able to relate cognitive style to any of the lateralized EEG testing because of insufficient numbers of subjects. However, we shall continue data-gathering in pursuit of this aspect of the investigation.

Tests which most often resulted in predictable EEG activation are as follows: (1) Arithmetic tasks almost always resulted in left hemisphere activation to a greater or lesser degree. However, even within this activation, there was shifting between left and right dominance. It is noteworthy that for many subjects the performance of mental arithmetic resulted in an EEG response which looked very much like the so-called "resting" period before and after testing. This suggests that our concept of "normal mental rest" should be re-evaluated inasmuch as this kind of rest appears to involve

important and relatively continual left hemisphere activation. Our most potent stimulator of right hemisphere activity for most subjects was the "mental trip task". During this task, the subject was asked to take a journey with eyes closed and attempt to visualize his journey. Most commonly the subject was asked to either walk from home to school or to walk through some familiar but complex journey, such as from our laboratory to a distant part of our medical center. Again, although the mental trip very often did produce significant right hemisphere activation (loss of power in the alpha range and narrowing of bandwidth in the alpha range), there still was oscillation between left and right activation during the performance of this task.

We are not yet in a position to completely evaluate the significance of power and bandwidth shifts as such and give appropriate weight to them. This further, more rational understanding of these findings awaits numerical analysis, autoregression analysis, and analysis of the variance of these data utilizing the University's Scientific Computing Center large, general purpose computer.

FUTURE PLANS

A. With enlargement of our computer capabilities we plan to re-analyze our data and enlarge the scope of future data analysis. This will specifically take the form of autoregression analysis of EEG spectra and a complex analysis of variance of EEG spectra in order to reveal small significant differences between EEG spectra not apparent when viewing analog plots of spectral displays.

B. We plan to utilize biotelemetry techniques now available in our laboratory. Broadcasting the EEG's of subjects from a small biotelemeter located on the subject's person will do away with the hard-wire connection between subject and EEG machine which is now necessary. Telemetered EEG's are often of higher quality than hard-wire EEG's because of the elimination of the long cable connection (with attendant noise pickup) between subject and amplifier. Furthermore, the subject is physically free to move about, feels more comfortable, and we would suspect, will be more motivated to work at the cognitive task in a moderately relaxed manner.

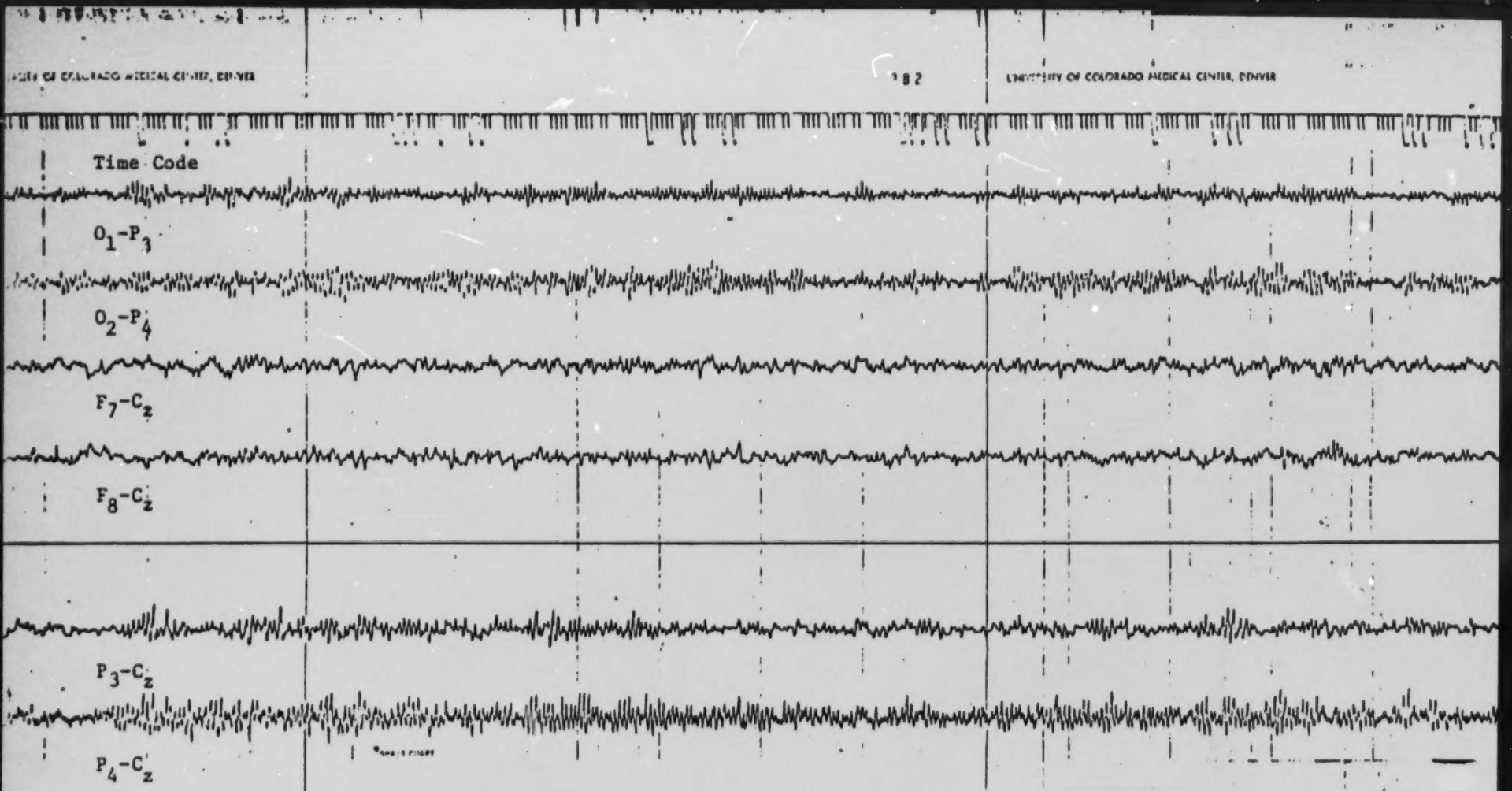
C. We plan to analyze the nature of the "normal" (in our experience) oscillation of "spectral dominance" between left and right hemisphere. Is this related to fluctuations in cognitive activity? Is it evidence of oscillating transfer of information between left and right? These are important questions requiring clarification.

D. To this end we have devised an "auditory embedded figures test" and an "embedded words test". In each test, the subject will be required to hear a "hidden" or "target" musical theme or word, "covered-over" by a major piece of music or listening to a story. The subject's task in the embedded music test is to detect and identify the hidden target musical theme within the major piece of music. In the embedded words test the subject's task is to detect and identify an "inappropriate" "target word" while listening to a story. All this is accomplished during EEG recording. Each task requires continual work, not intermittent work. "Moment of discovery" of the hidden word or music should give a sharper point of EEG response. Furthermore, we will more carefully and precisely "pace" our other tasks so that the transition from rest-to task-to rest can be accurately timed and analyzed.

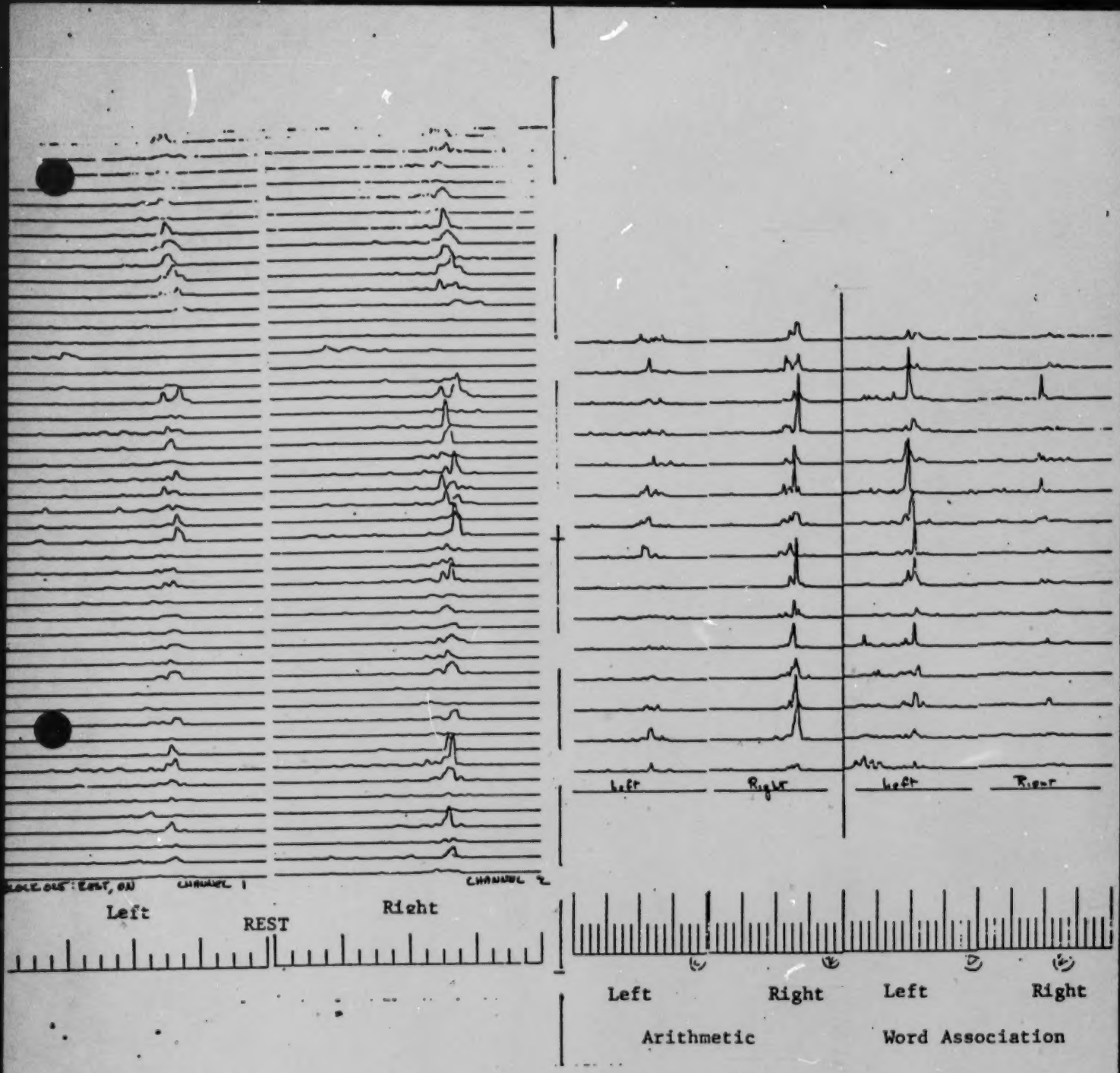
E. In September, with our newly acquired pool of children with specific learning disturbances, we will follow-up this preliminary speculation that many of these children may suffer a defect in or disturbance of necessary oscillating transfer of activation between the hemispheres.

F. We suspect that "normals" who do not show this inter-hemisphere transfer may, however, show other deficits (i.e. they "pay a price") in cognitive functioning for which they have learned to compensate. This would be in keeping with Levy's finding that bright, left-handed people have small cognitive deficits due to inter-hemisphere interferences to which they have adapted.

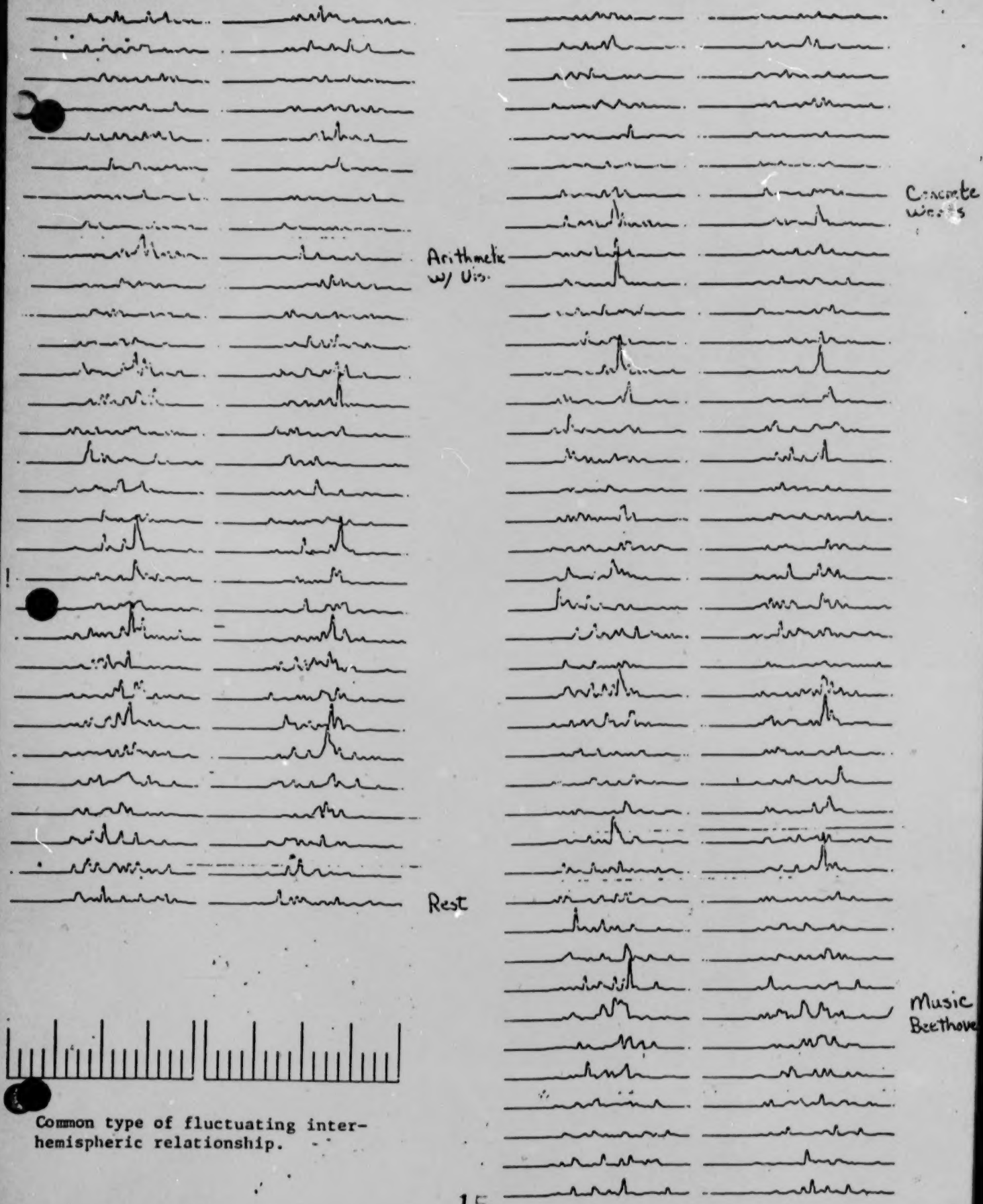
G. A normative, developmental study of normal children must be done in order to understand and evaluate these reported findings and the questions they raise. This we plan to attempt with new funding.



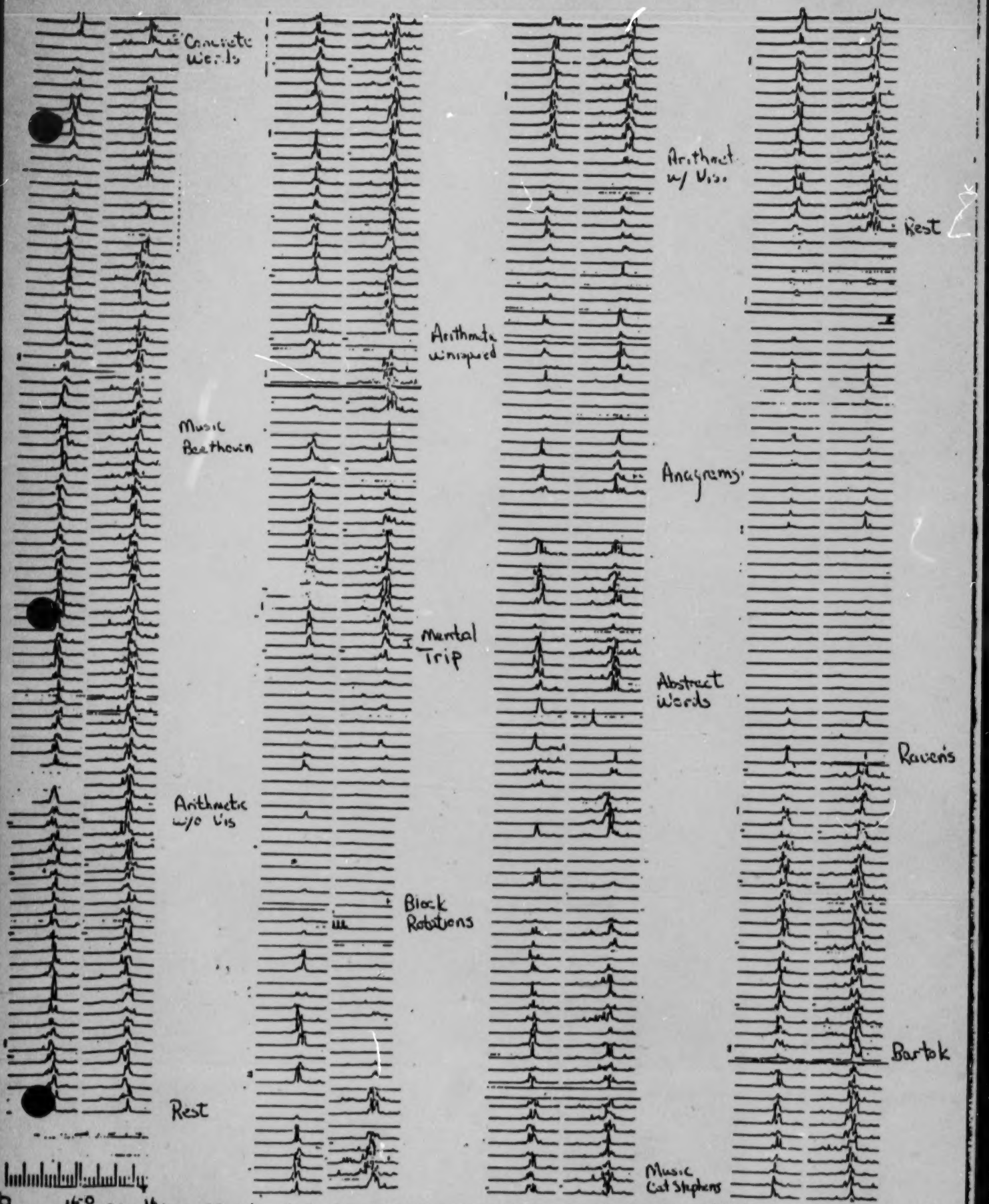
EEG - 40 second epoch during association to <u>concrete words</u>.
Note lower amplitude (i.e. "EEG-activation") in
O_1-P_3 (left hemisphere) derivation.



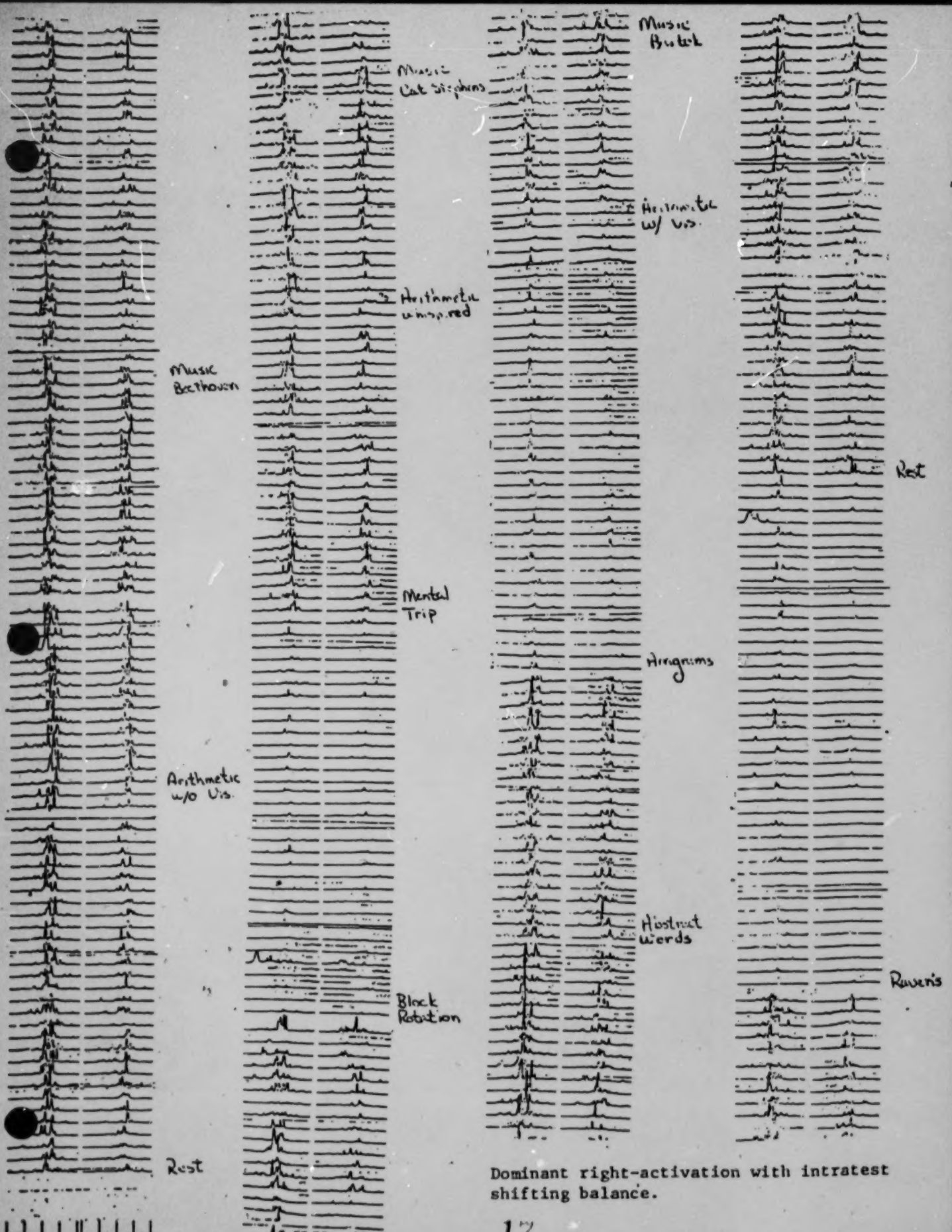
One subject: Illustrating expected lateral congruence with cognitive task. Note: At rest, left side is "activated".



Common type of fluctuating inter-hemispheric relationship.



13 y/o girl showing invariant inter-hemispheric relation-



Dominant right-activation with intratest shifting balance.

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APPENDIX

COGNITIVE TESTS: REFERENCE SOURCES

1. Physiognomic Cue Test

   Rosett, H.L., Robbins, H., and Watson, W.S. Standardization and construct validity of the physiognomic cue test. Perceptual and Motor Skills. 1967, 24, 403-420.

   This tests the cognitive control principle of physiognomic reactivity.

2. Mental Block Rotations

   Vandenberg, S.G. A twin study of spatial ability. Multivariate Behavioral Research. 4 (3), July, 1969.

3. Raven's Progressive Matrices

   Raven, J.C. Standard Progressive Matrices, Sets A, B, C, D, and E. London, H.K. Lewis and Co. Ltd., 1958.

4. Stroop Test

   Gardner, R.W. and Lohrenz, L.J. Some old and new group tests for the study of cognitive controls and intellectual abilities. Perceptual and Motor Skills. 1969, 29, 935-950.

5. Contrast Reactivity Test

   Gardner, R.W. Contrast reactivity: Situational and temporal stability of cognitive control. Perceptual and Motor Skills. 1973, 36, 617-618.

6. Schematizing Test of Leveling-Sharpening

   Gardner, R.W. and Lohrenz, L.J. Schematizing Test Procedure. July, 1967.

   also see: Cognitive Control. Gardner, R.W. et al. Psychological Issues, vol. 1, No. 4, Monograph 4, 1959, I.U.P., New York.

7. Rod and Frame

   Oltman, P.K. A portable rod and frame apparatus. Perceptual and Motor Skills, 1968, 26, 503-506.

   For establishing the cognitive control principle of field dependence-field independence.

8. Embedded Figures and Children's Embedded Figures

   Witkin, H.A., Oltman, P.K., Rasbin, E., and Karp, S.A. A manual for the embedded figures test. Palo Alto, California, Consulting Psychologists Press, Inc., 1971.

9. Test for Color Blindness

   Ishihara, S. Tests for Color Blindness. Tokyo, Japan, Kanehara Shuppan, Co. Ltd

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(a) the cognitive principle of "leveling-sharpening". Sebastiano Santostefano, 1971.

(b) Santostefano, S. Cognitive Controls versus Cognitive Styles. Seminars in Psychiatry, Vol. 1, No. 3, 1969, 291-317.

12. Word Beginnings and Endings Test

op cit., Vandenberg, S.G.

13. Things Category Test

op cit., Vandenberg, S.G.

14. Card Rotation Test

op cit., Vandenberg, S.G.

15. Surface Development Test

op cit., Vandenberg, S.G.

16. Witelson, S.F. Hemispheric specialization for linguistic and nonlinguistic tactual perception using a dichotomous stimulation technique. Cortex, 1974, 10, 3-17.

DO NOT WORK ON THIS TEST UNTIL YOU HAVE THOROUGHLY READ THE INSTRUCTIONS

Each item in this test consists of a drawing on one side of the page and a corresponding scale to the right of the drawing. Look at the drawing at the left. Then look to the scale on the right where you will find two alternatives separated from each other by six points. Check the point that indicates what the figure looks like to you.

For example, look at drawing (A) below and then at the two alternatives to the right of it - "Seven lines pointed inward" and "sun rising or setting." Indicate your rating in the following manner:

Check #1 if the drawing looks like "seven lines pointed inward" to you.
Check #2 if the drawing looks something like "seven lines pointed inward" to you.
Check #3 if the drawing looks very little like "seven lines pointed inward" but is more like "seven lines pointed inward" than it is like a "sun rising or setting."
Check #4 if the drawing looks very little like a "sun rising or setting" but is more like a "sun rising or setting" than it is like "seven lines pointed inward."
Check #5 if the drawing looks something like a "sun rising or setting" to you.
Check #6 if the drawing looks like a "sun rising or setting" to you.

ALTHOUGH EACH OF THE DRAWINGS COULD BE SEEN IN TERMS OF EITHER ALTERNATIVE, YOU ARE REQUESTED TO CHECK YOUR FIRST IMPRESSION.

A)

Seven lines pointed inward ——— Sun rising or setting
(1) (2) (3) (4) (5) (6)

1)

Two arcs — Open mouth

2)

A line — Feeling of sadness

3)

Waves of water — Border design

4)

Seven lines — Feeling of excitement

5)

Triangles and lines — Boats sailing

6)

Line _____ Feeling of monotony

7)

Cars crashing _____ Two rectangles

8)

Arrow _____ Feeling of directness

9)

Spiral _____ Whirlpool

10)

Line _____ Feeling of happiness

11)

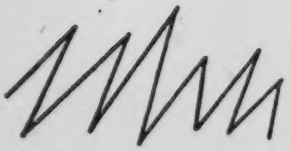
Sheets of rain — Diagonal lines

12)

Peacefulness — Curved line

13)

Letter "h" — Tilted chair

14) 

Jagged line — Feeling of being upset

Falling blocks — Four squares

16)

Feeling of smallness ——— Dot in a circle

17)

Spiral ——— Twisting tornado

18) □

Square ——— Feeling of smallness

19)

Lightning striking ——— Jagged line

20)

Feeling of stiffness ——— Rectangle

21)

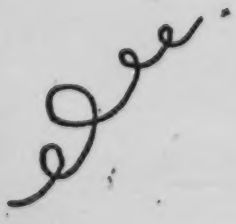
Cluster of lines ——— Waterfall

22)

Trapezoid ——— Feeling of cruelty

23)

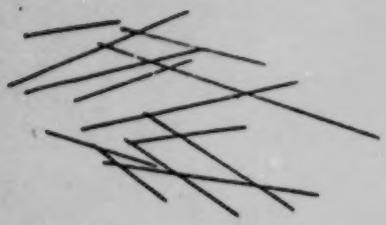
Raised eyebrows ——— Small arcs

24) 

Looping line ——— Feeling of happiness

25)

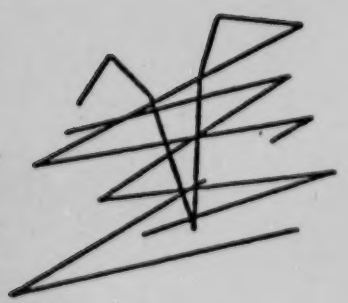
Circle and two tangents ——— Falling object

26) 

Feeling of sadness ——— Random lines

27)

Small ovals ——— Falling droplets

28) 

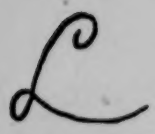
Design ——— Feeling of rage

29)

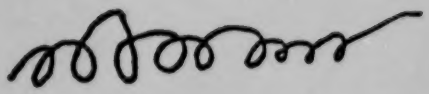
Tree ——— Rising atomic blast

30)

Plant ——— Feeling of yearning or desire

31) 

Letter "l" ——— Arm that beckons

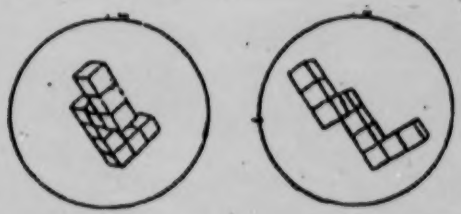
32) 

Spiral ——— Feeling of exertion or strain

MENTAL ROTATION TEST

INSTRUCTIONS

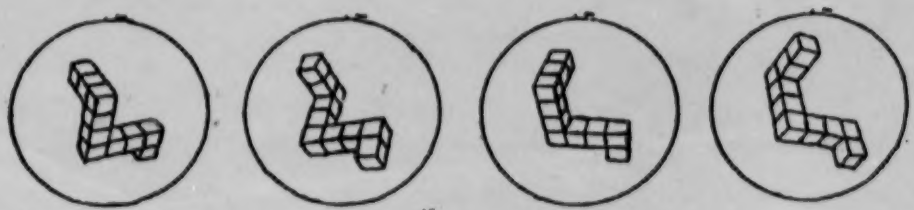
Note that these are all pictures of the same object which is shown from different angles. Try to imagine moving the object (or yourself with respect to the object), as you look from one drawing to the next.



Next, satisfy yourself that these two drawings show a different object, in which two individual blocks are arranged somewhat differently so that you can not "rotate" them to be identical with the object shown in the first 5 drawings.

Now look at this object:

Two of these four drawings show the same object. Can you find these two? Place a small check mark below them.



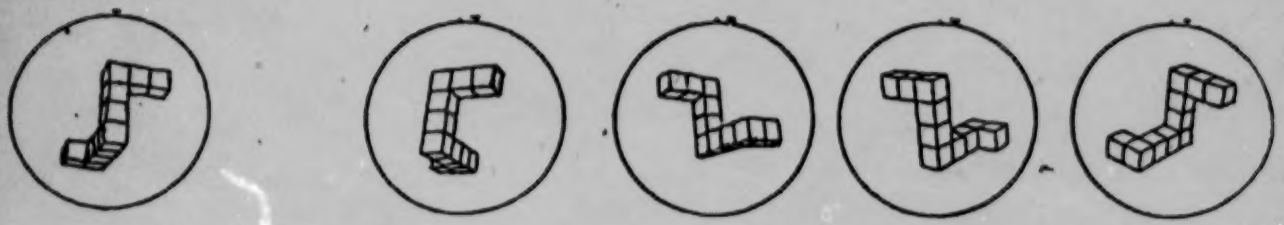
1 2 3 4

PLEASE CONTINUE ON THE NEXT PAGE.

If you circled number 1 and 3, you were correct.

Now try the next example.

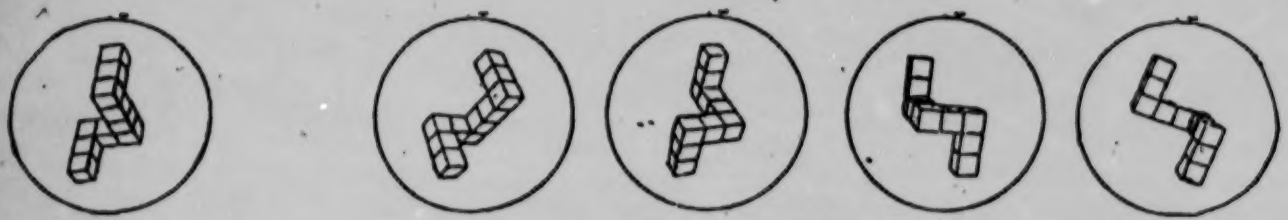
Again, which two drawings of the four on the right show the same object as the one on the left. Circle the number under those two.



1 2 3 4

The test administrator will tell you which two are right.

If you are finished with this one, try the next item.
Circle <u>two</u> numbers.



1 2 3 4

There are <u>always</u> <u>two</u> drawings of the same object as the one on the left.

When the signal is given, turn to the next page.

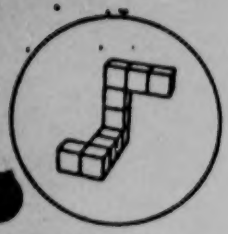
There are always <u>two</u> and <u>only</u> <u>two</u> correct answers for each item.

There are 20 items so the maximum possible is 40.

Most people will not be able to finish because only 10 minutes are available for this in order to keep the total testing time within reasonable limits.

PLEASE <u>DO NOT TURN THIS PAGE</u> UNTIL ASKED TO DO SO.

IDE



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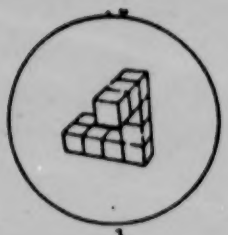

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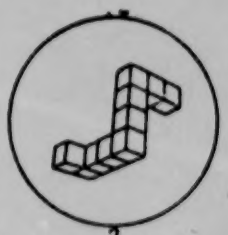

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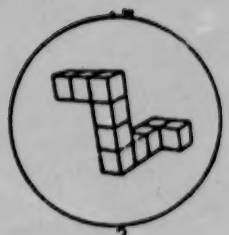

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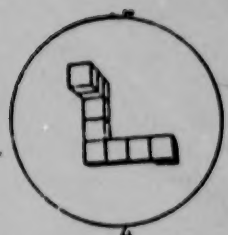

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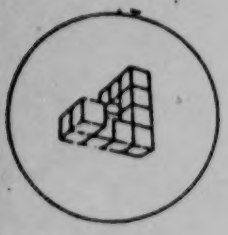

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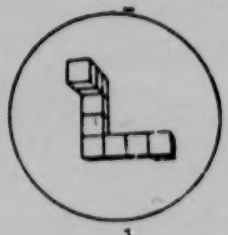

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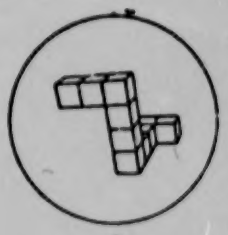

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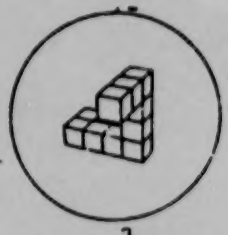

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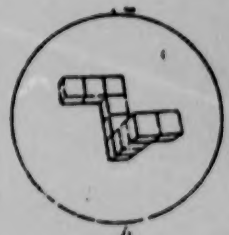

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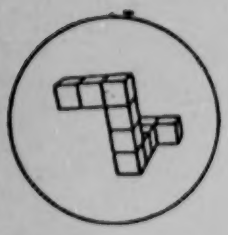

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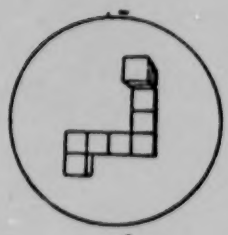

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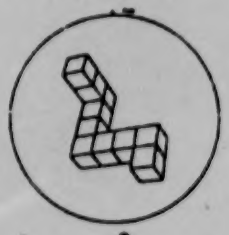

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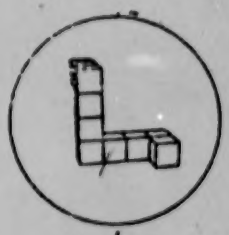

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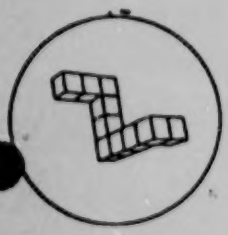

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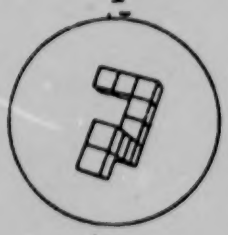

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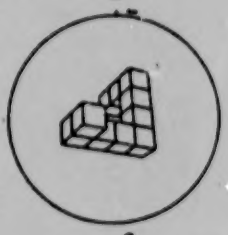

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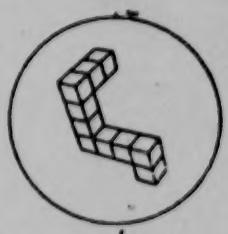

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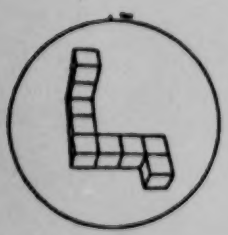

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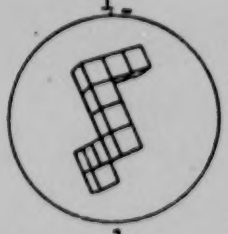

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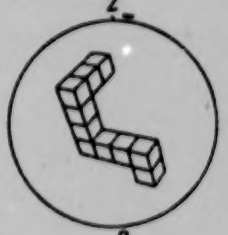

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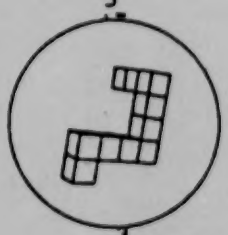

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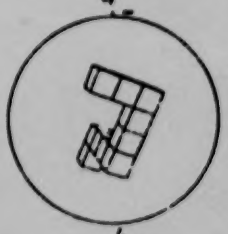

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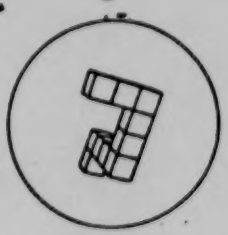

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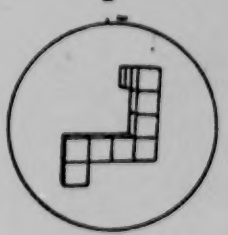

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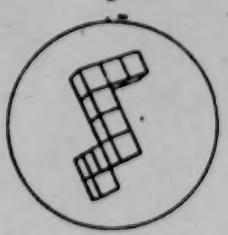

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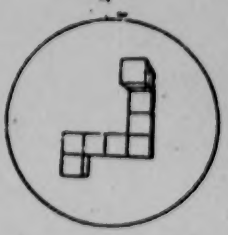

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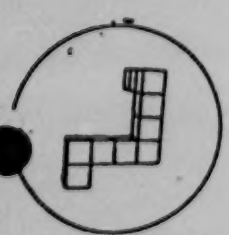

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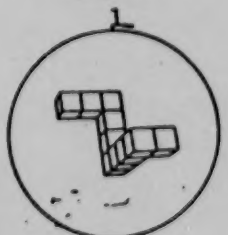

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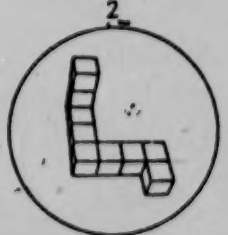

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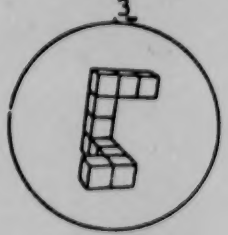

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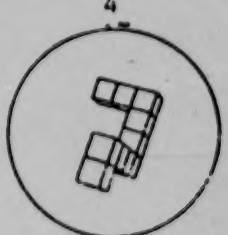

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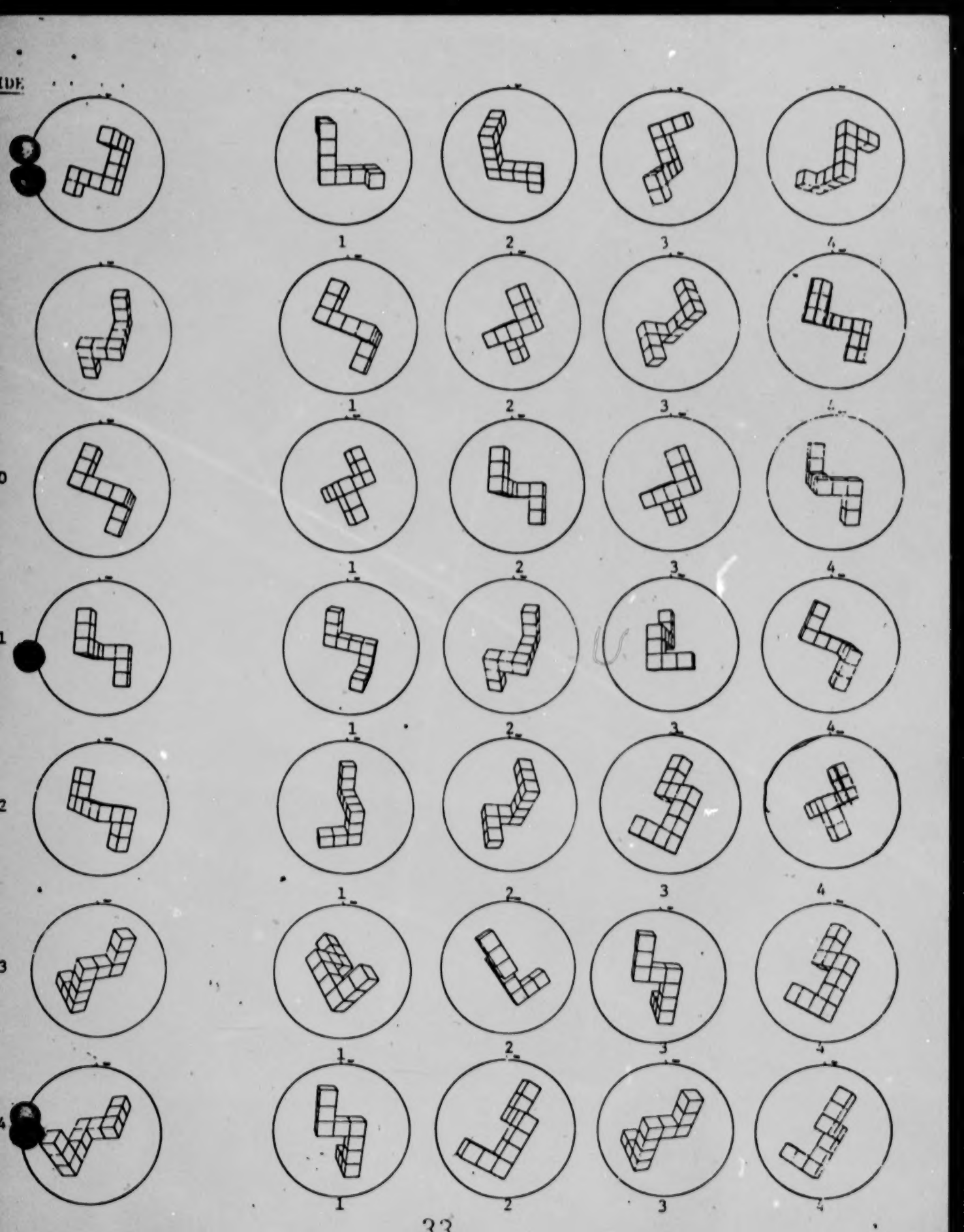
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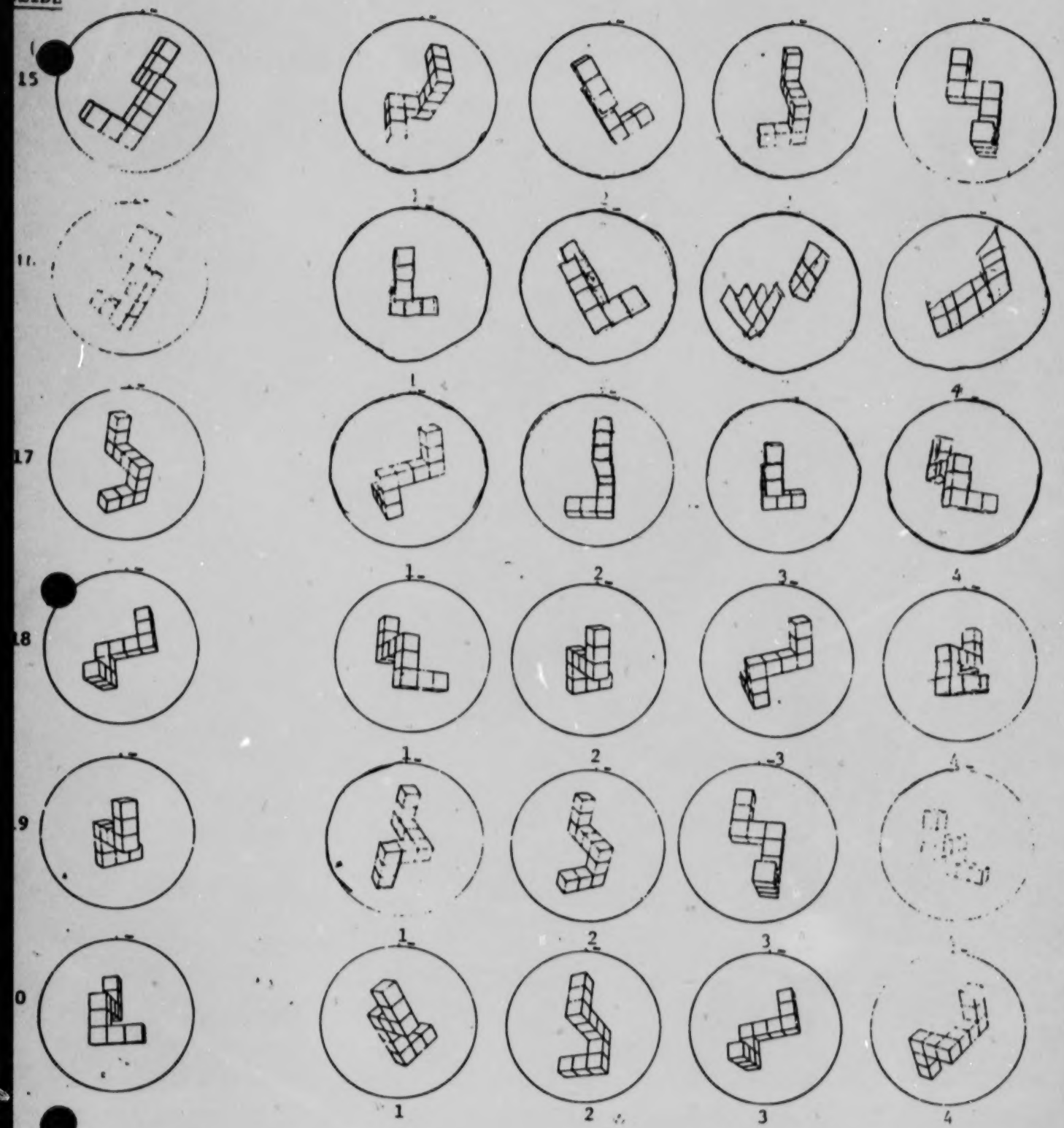
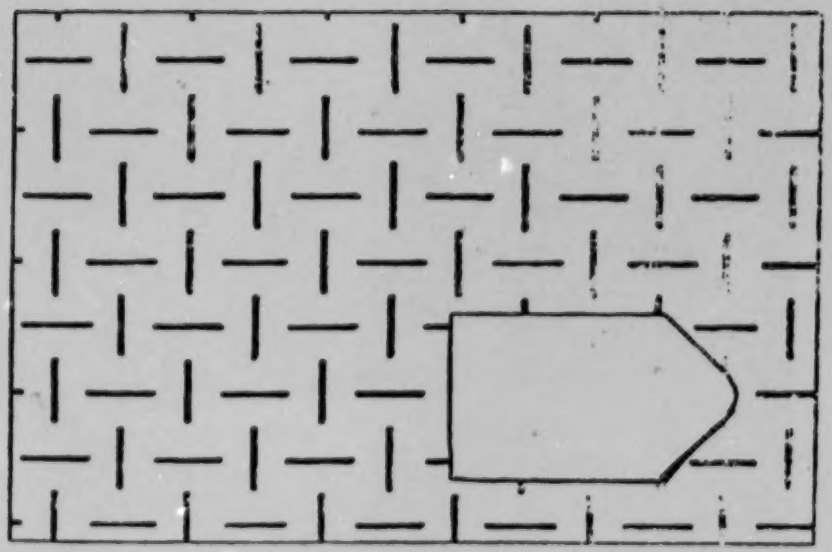
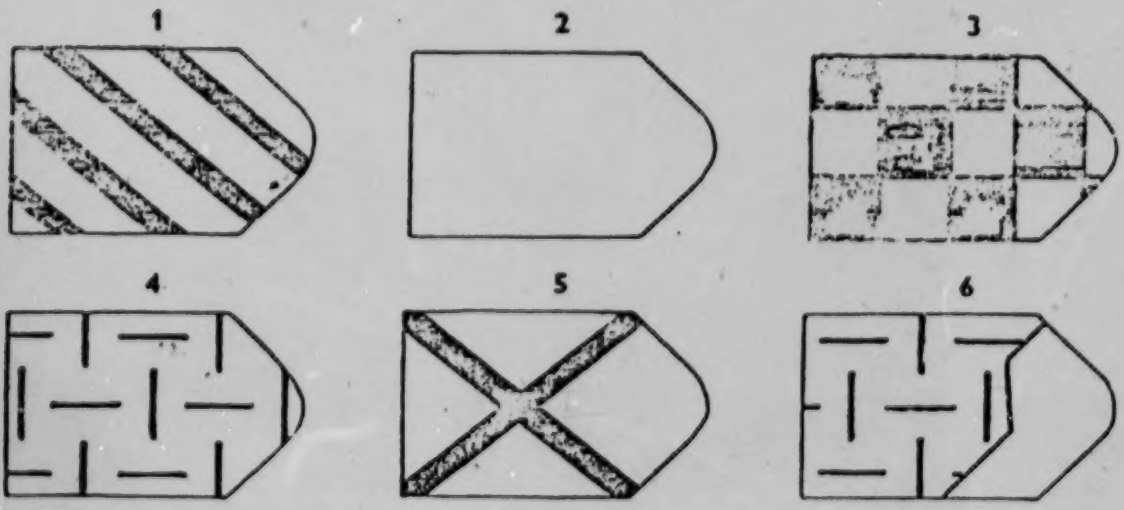


SET A

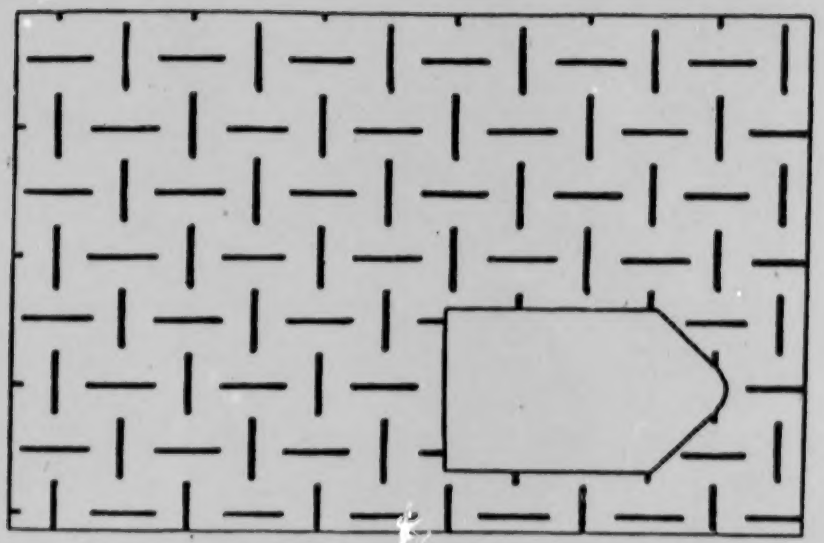
A 1

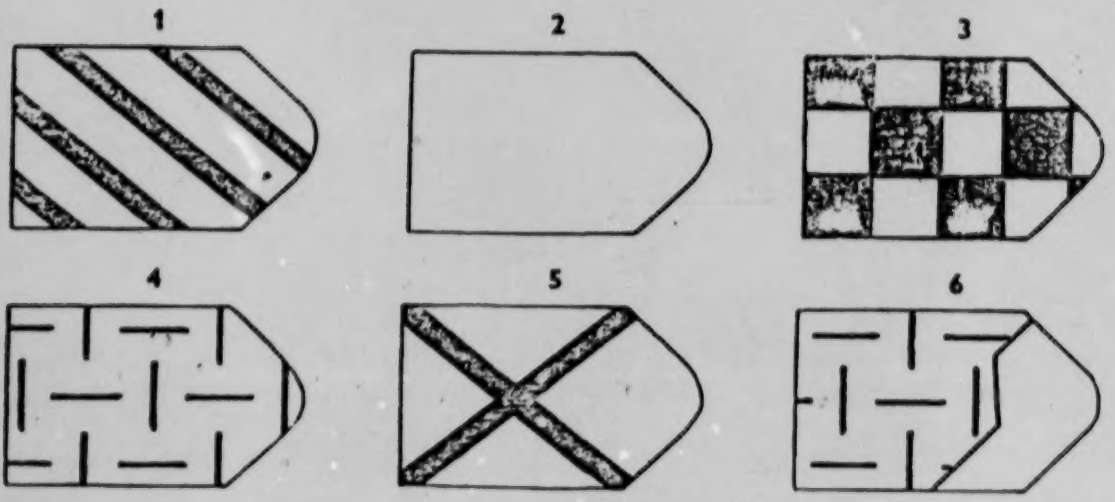




SET A

A 1





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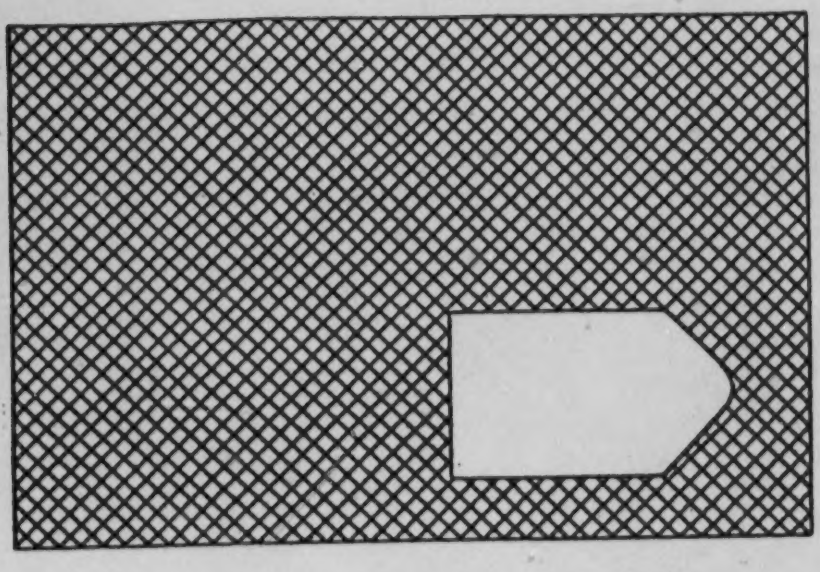
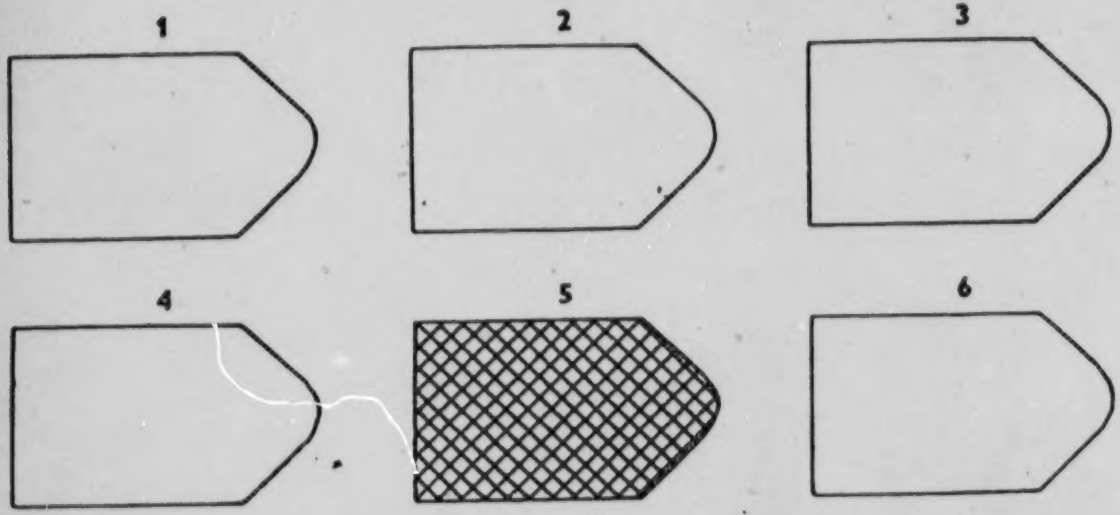
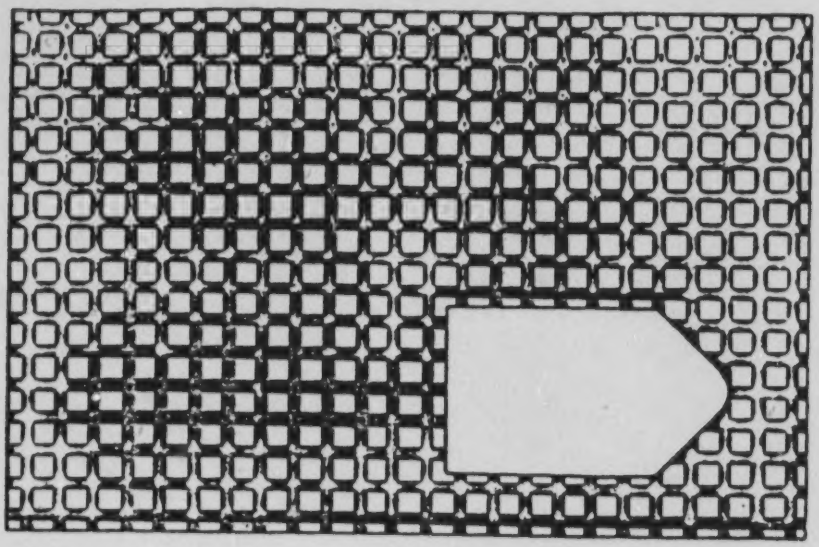
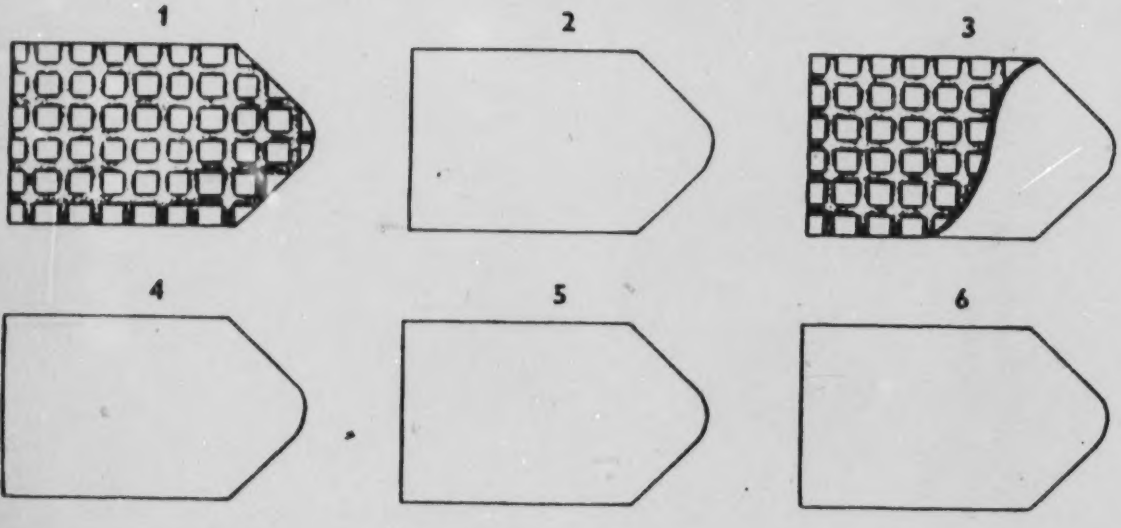
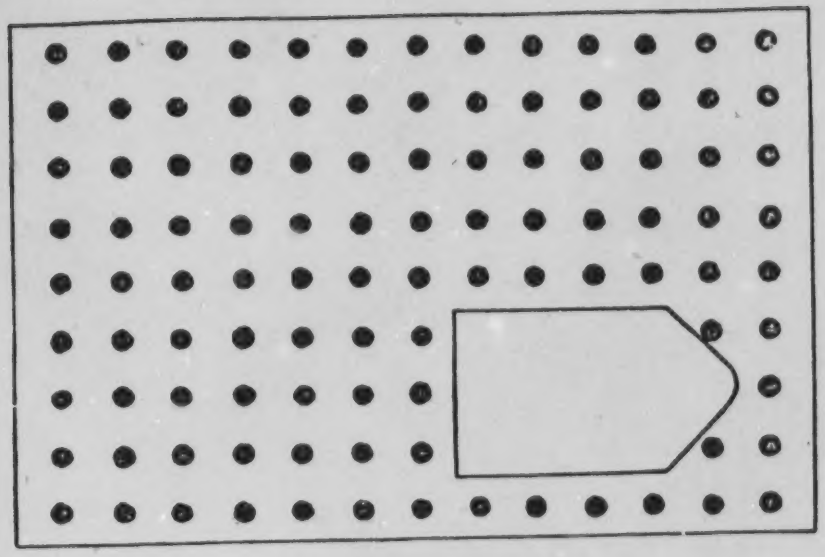


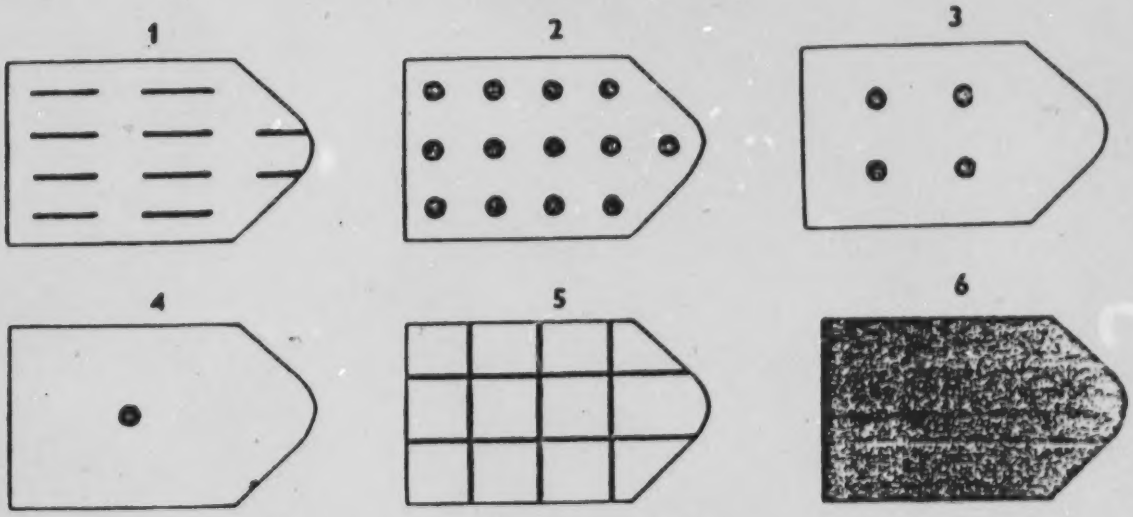


A 3





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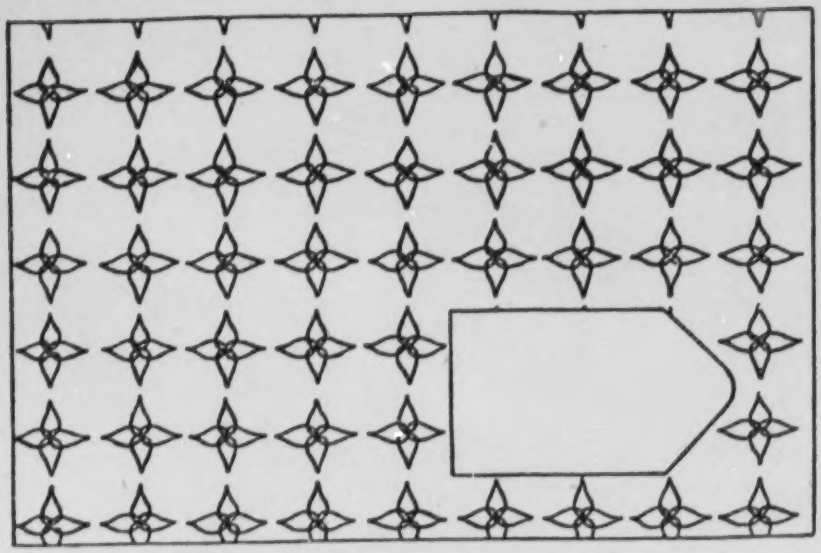

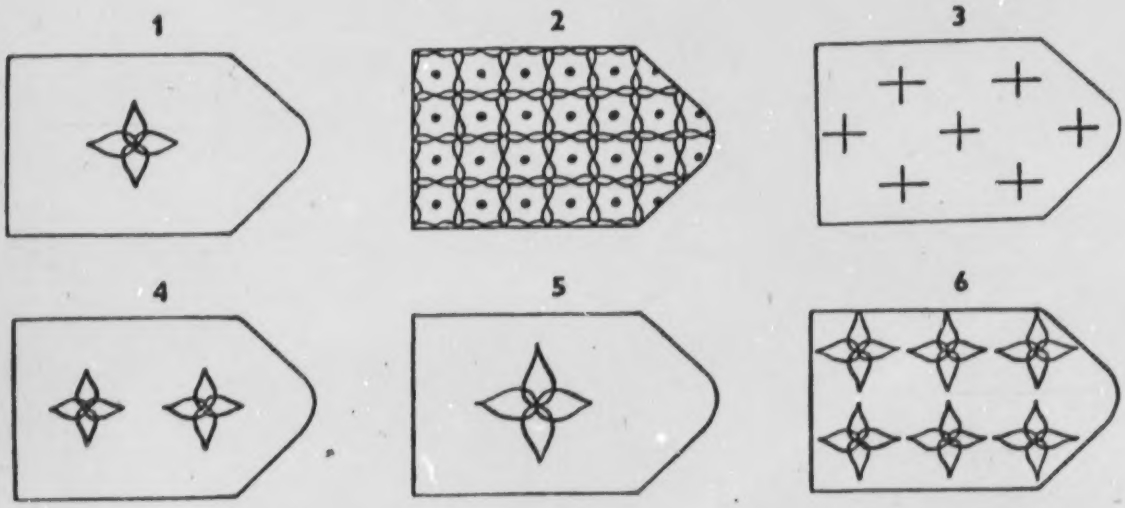
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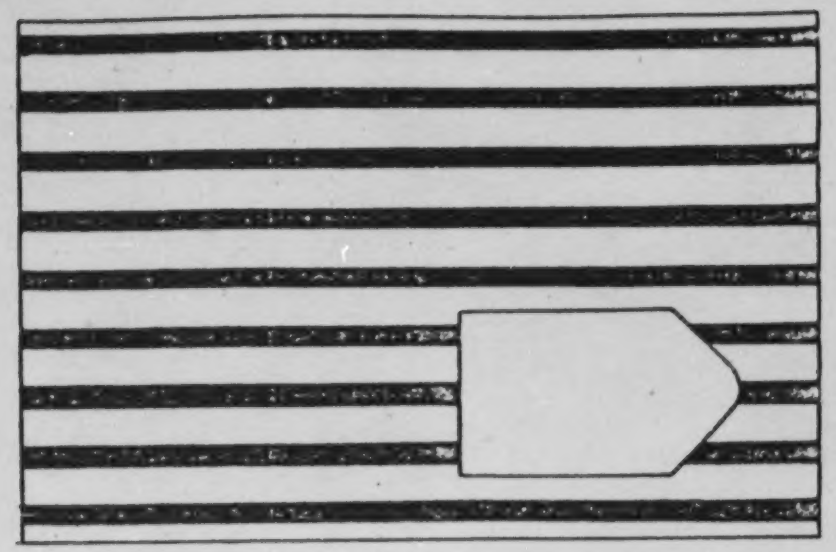

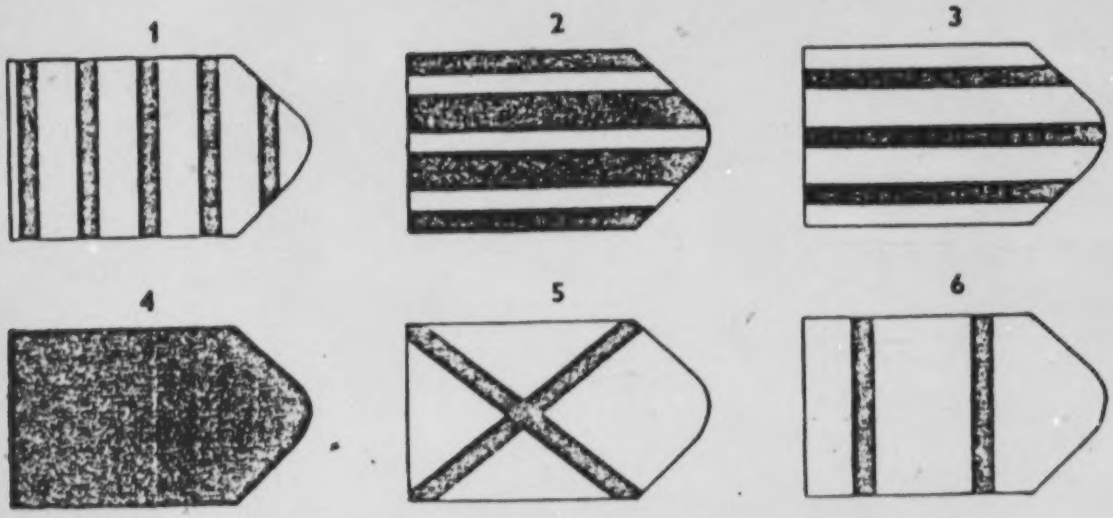

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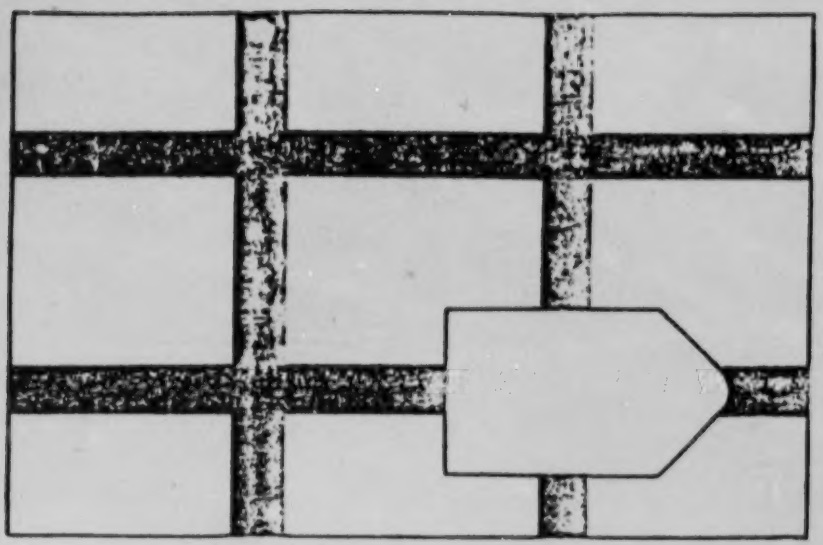

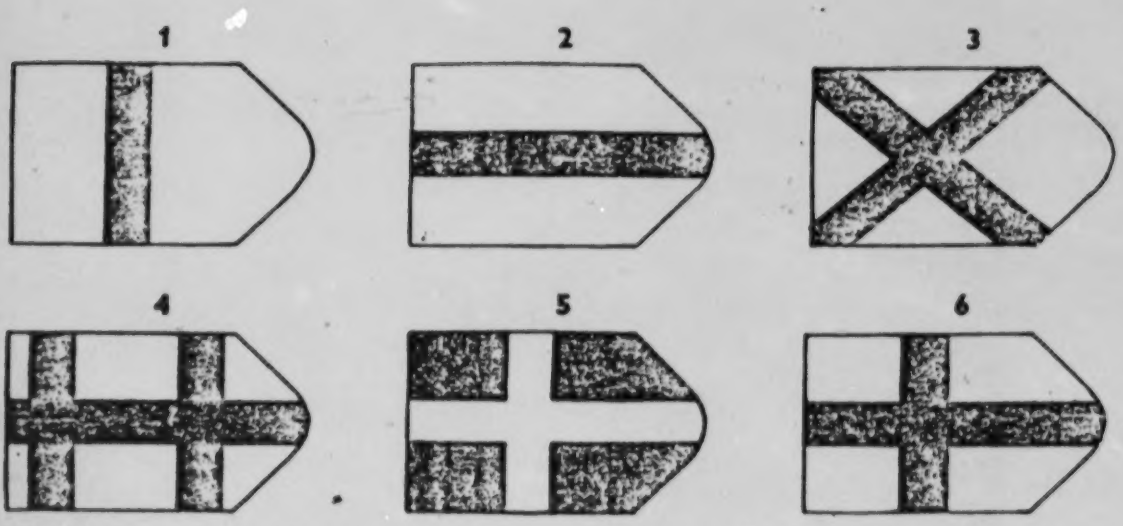

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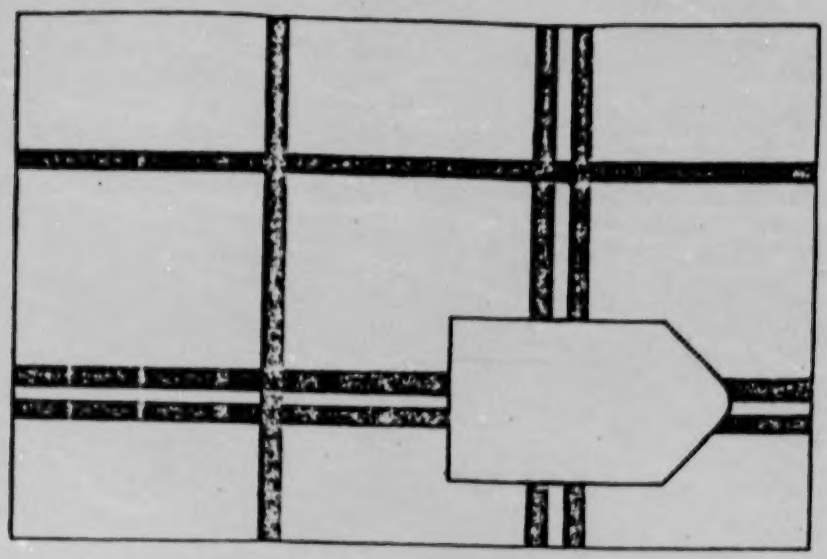

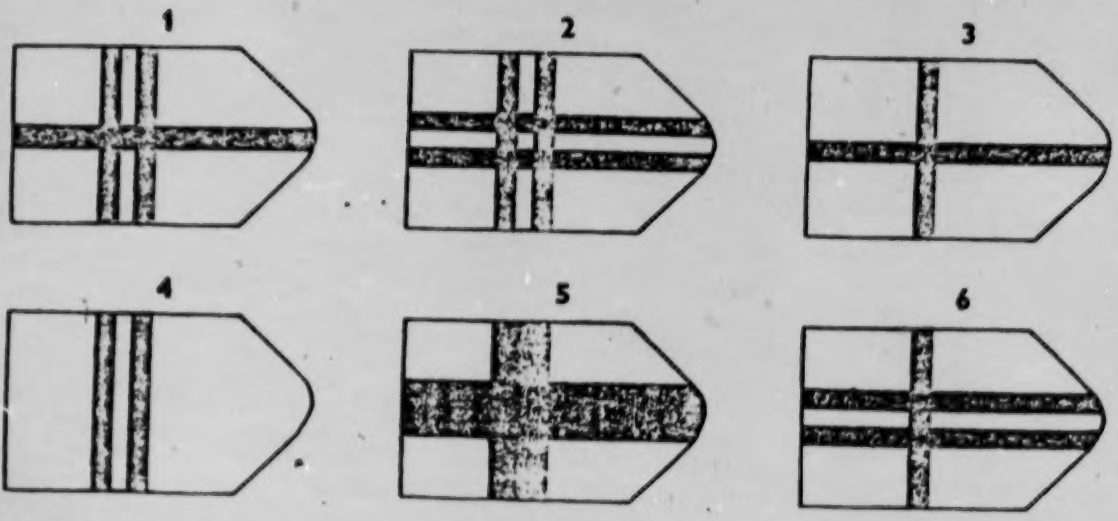

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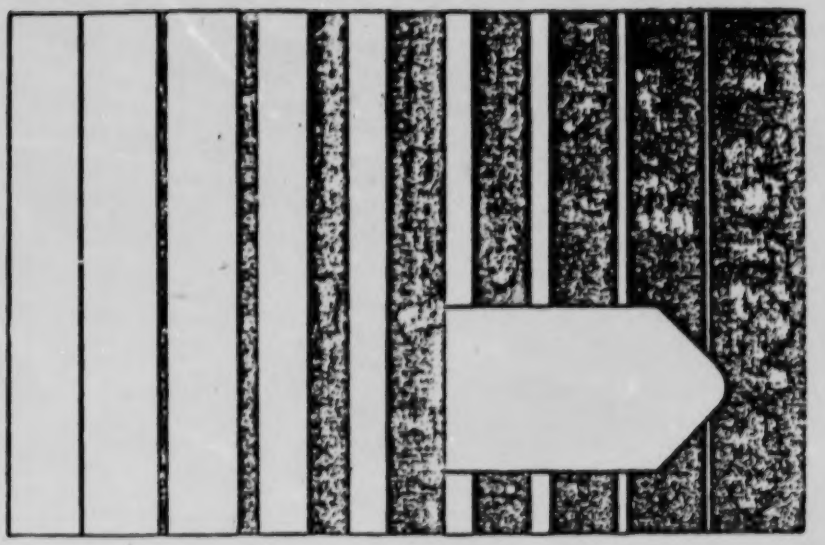

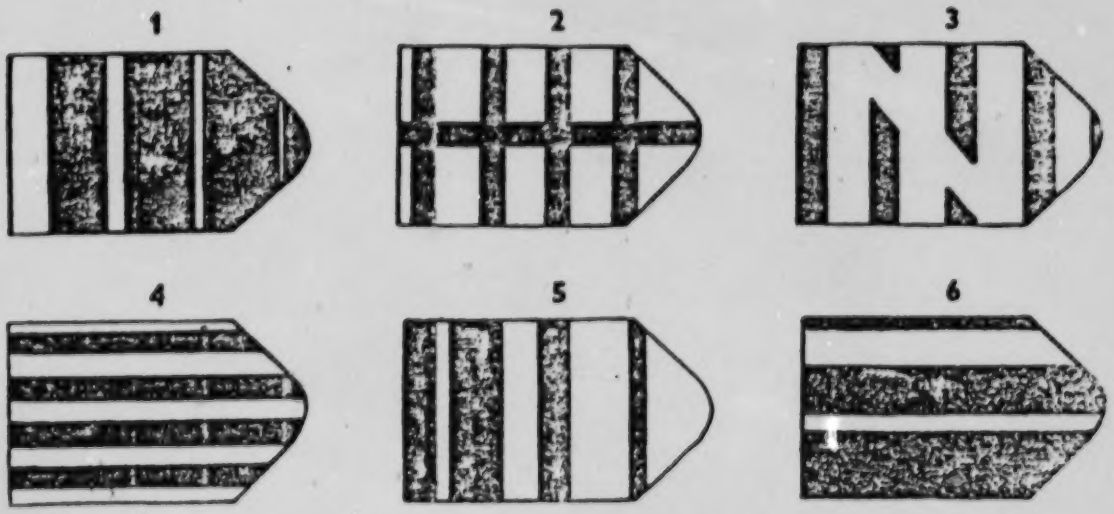

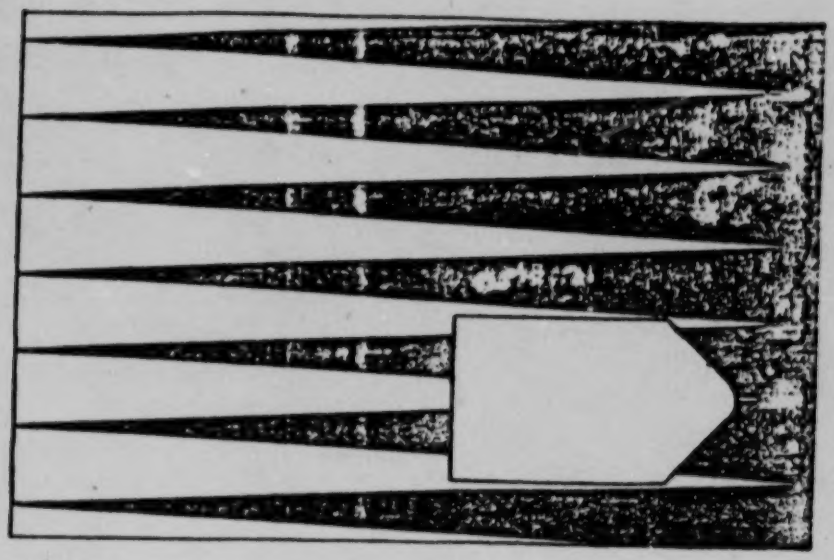

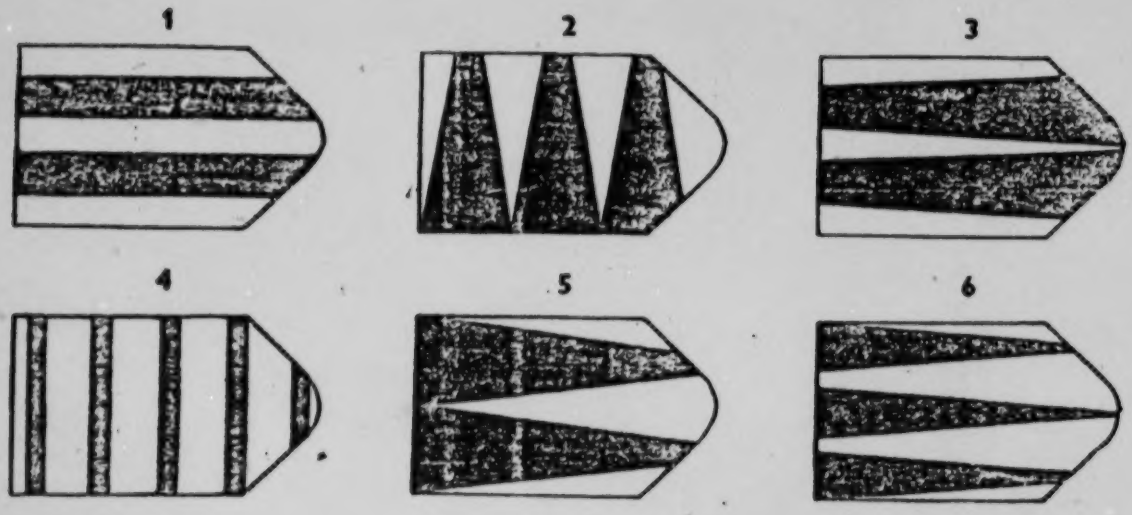
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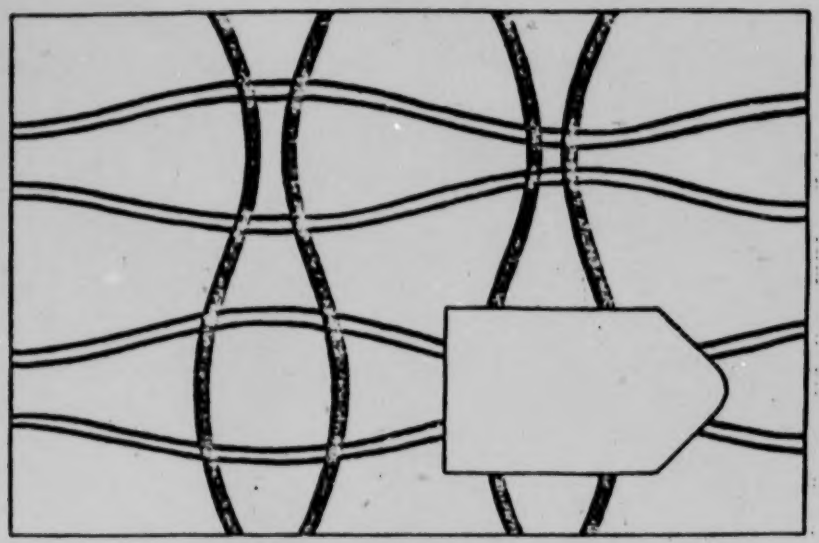

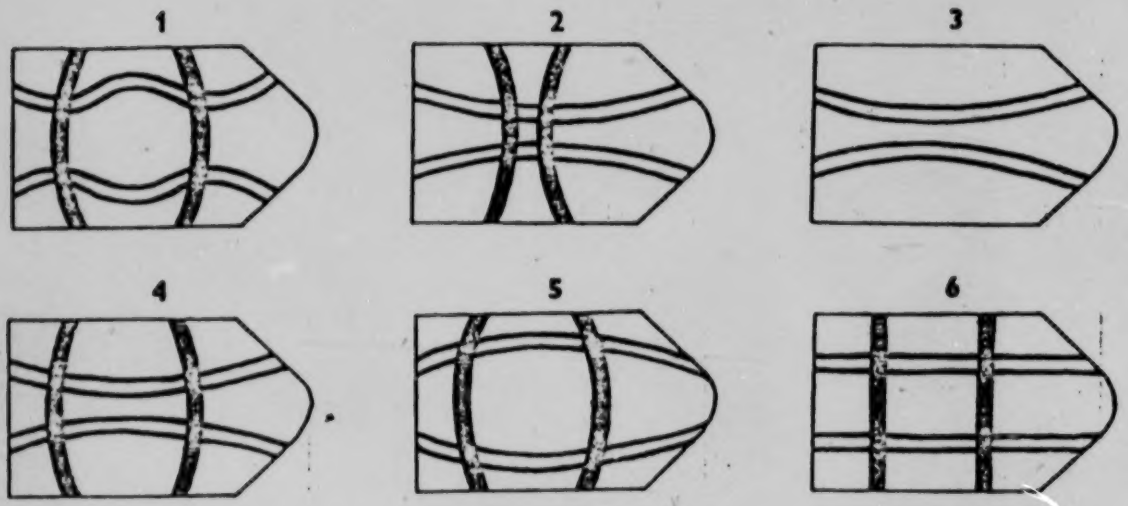
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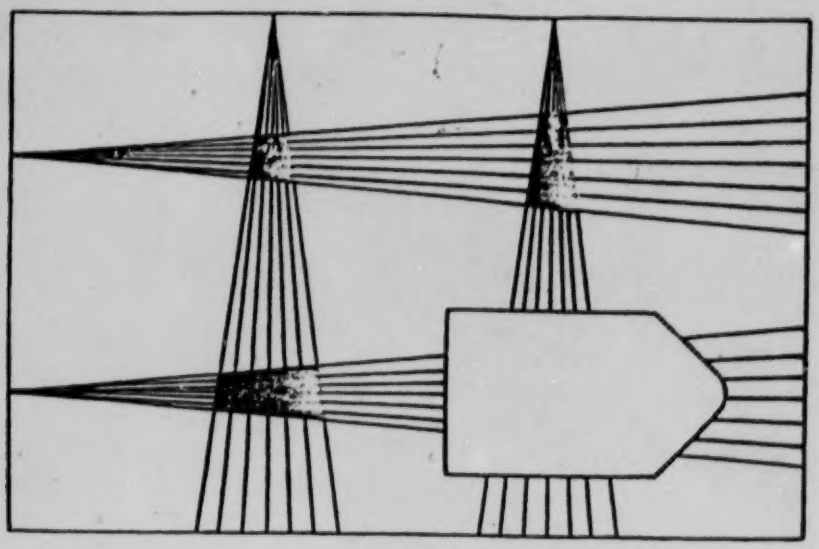

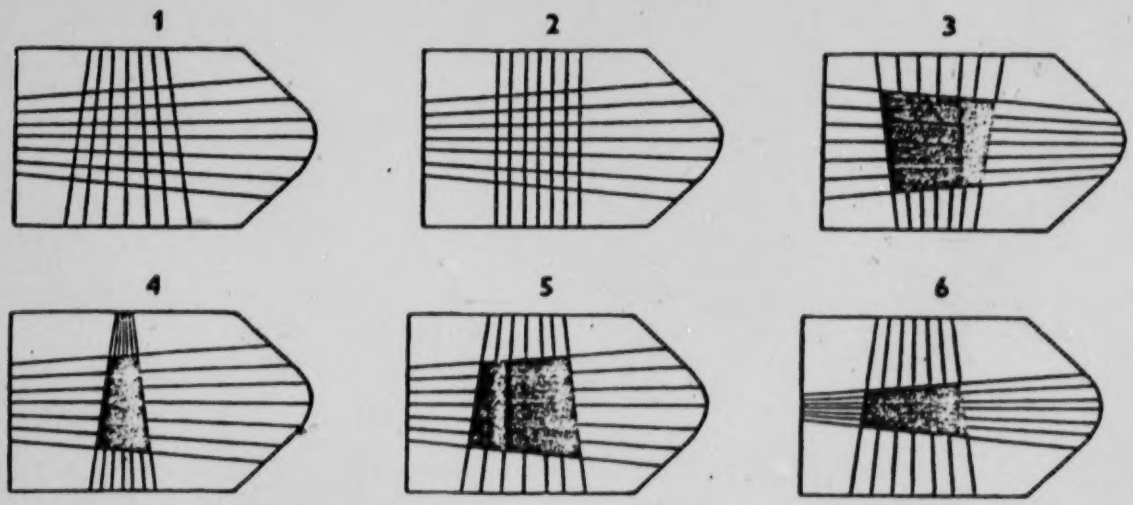

SET B

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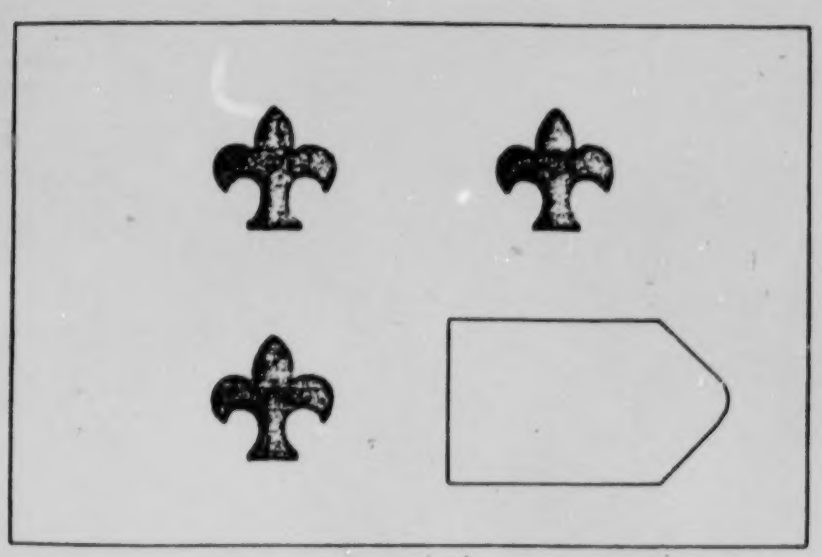

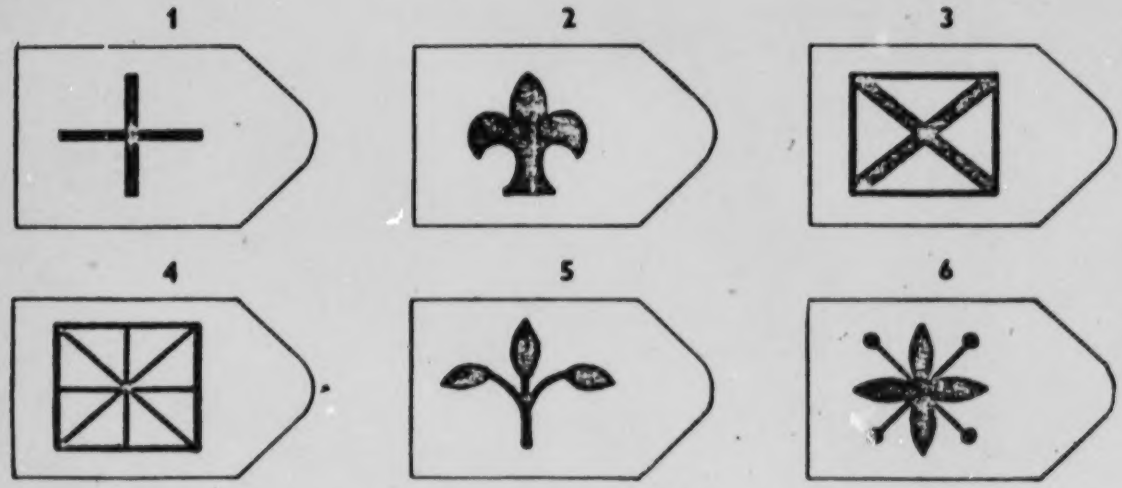

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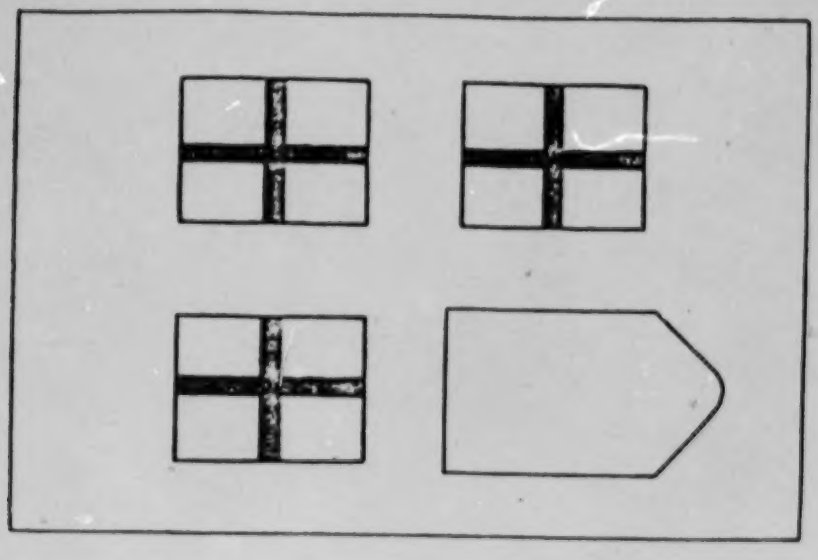

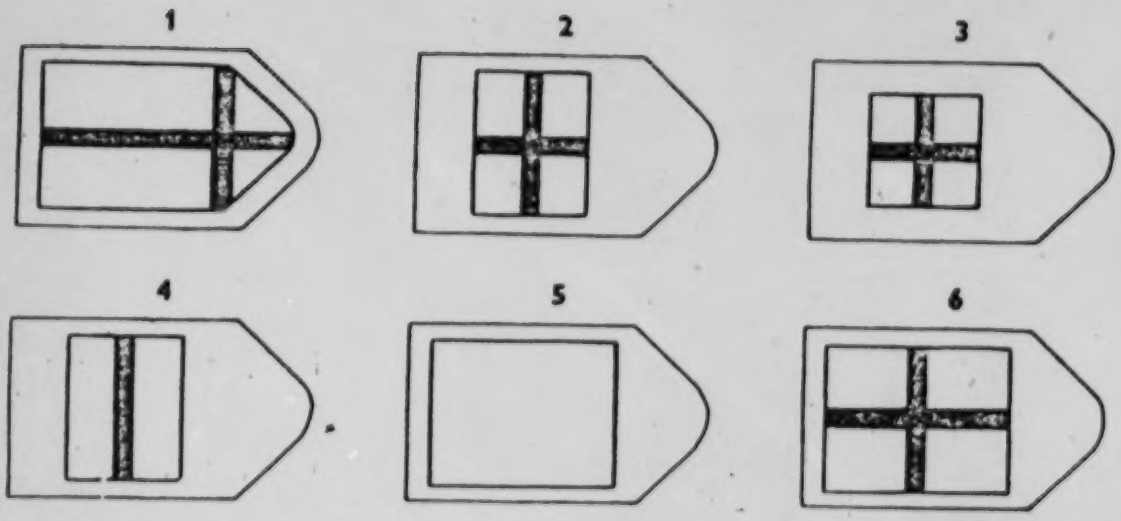

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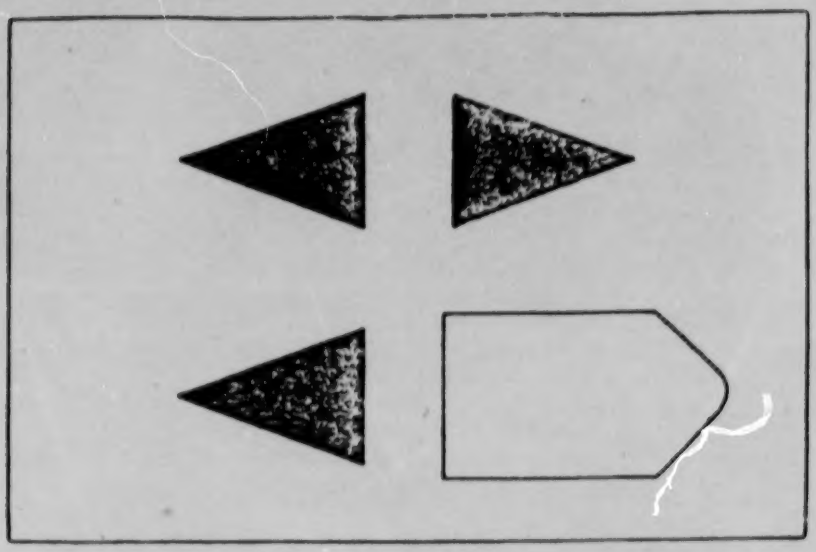

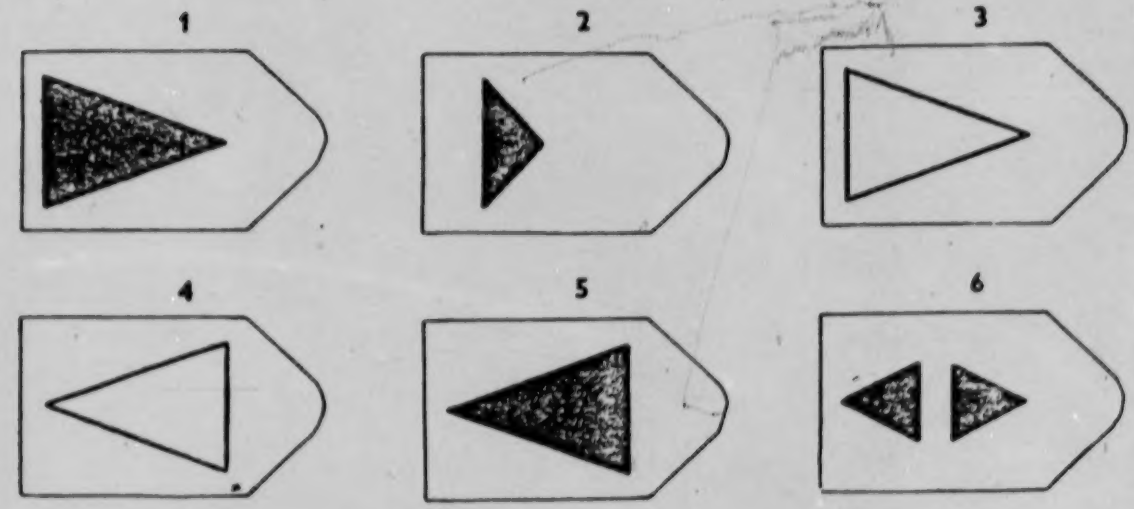

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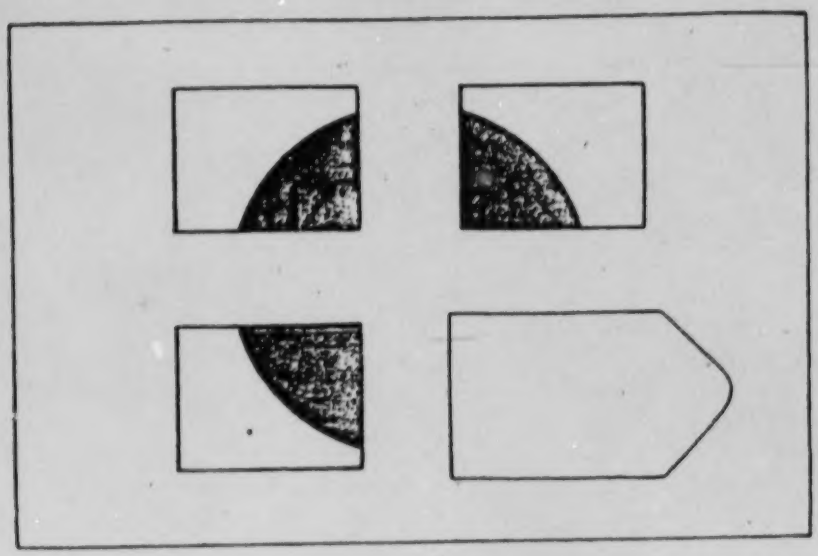

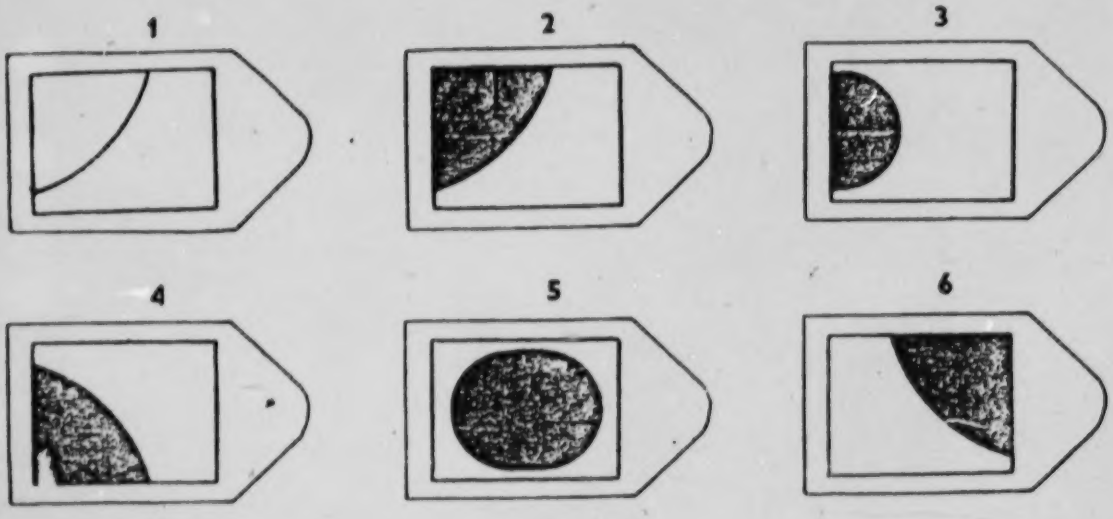

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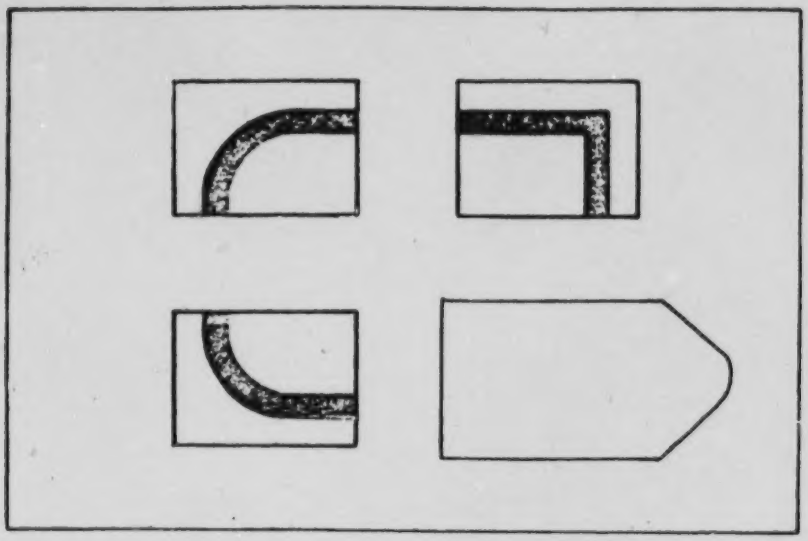

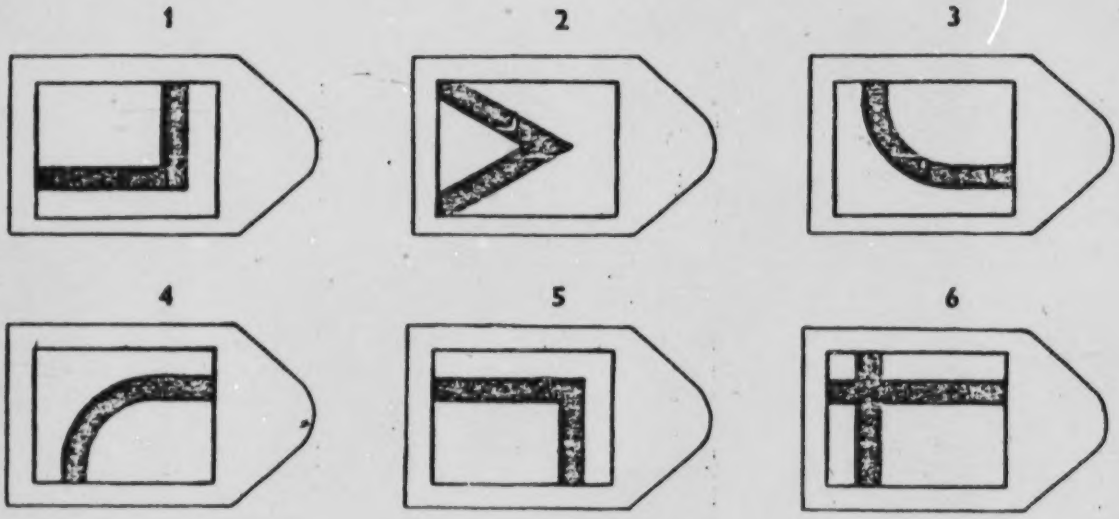

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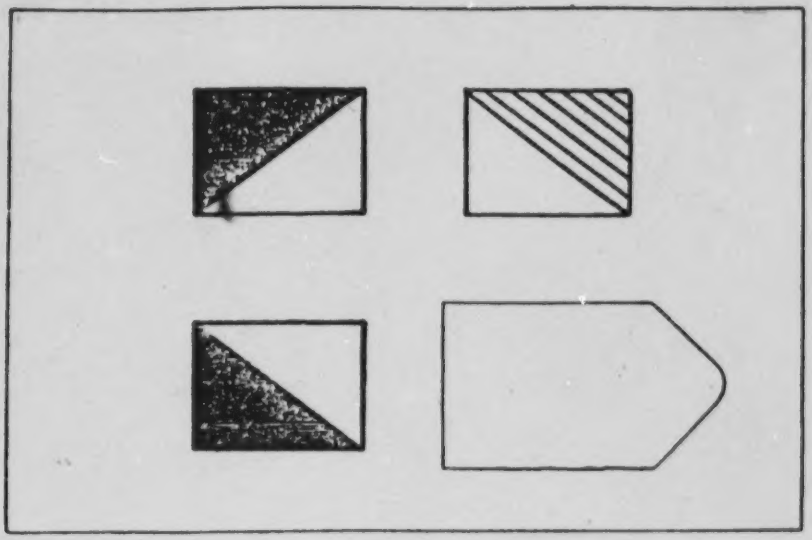

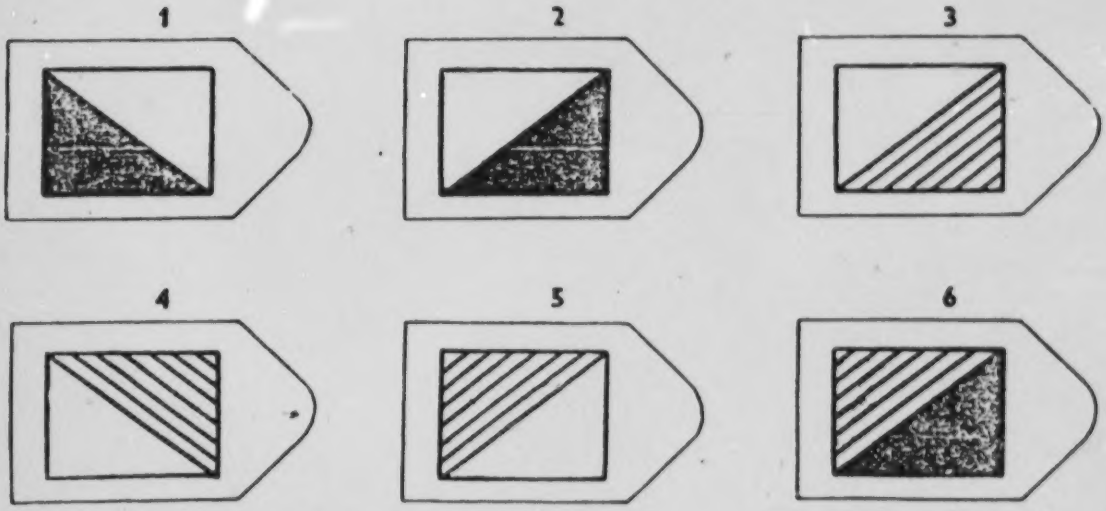

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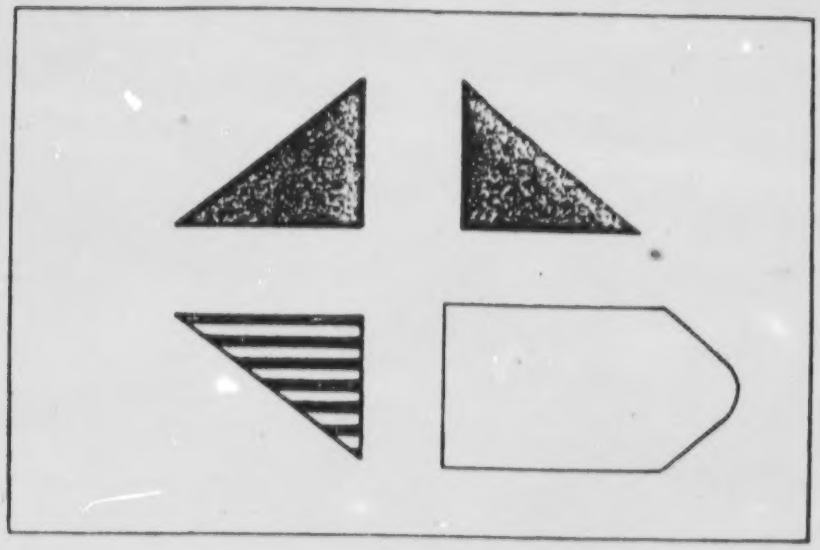

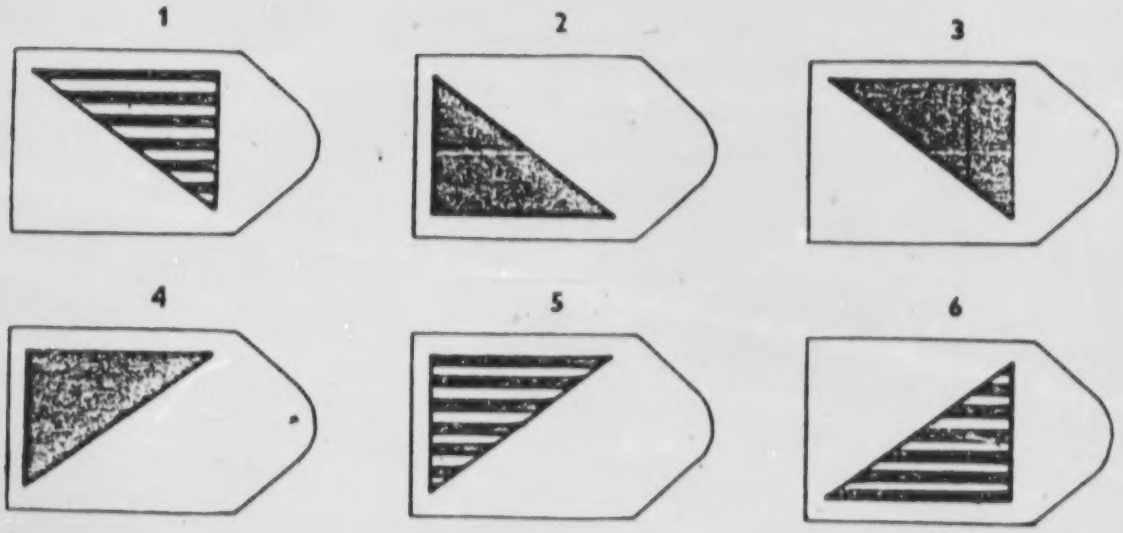

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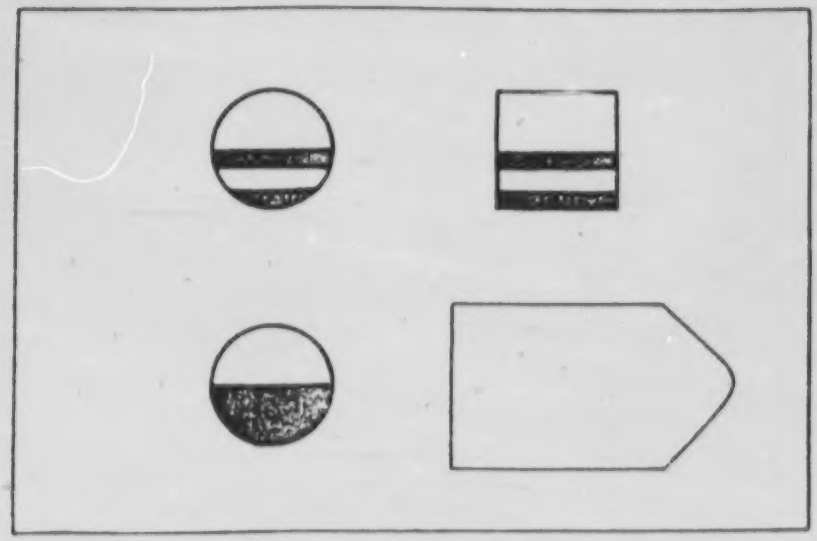

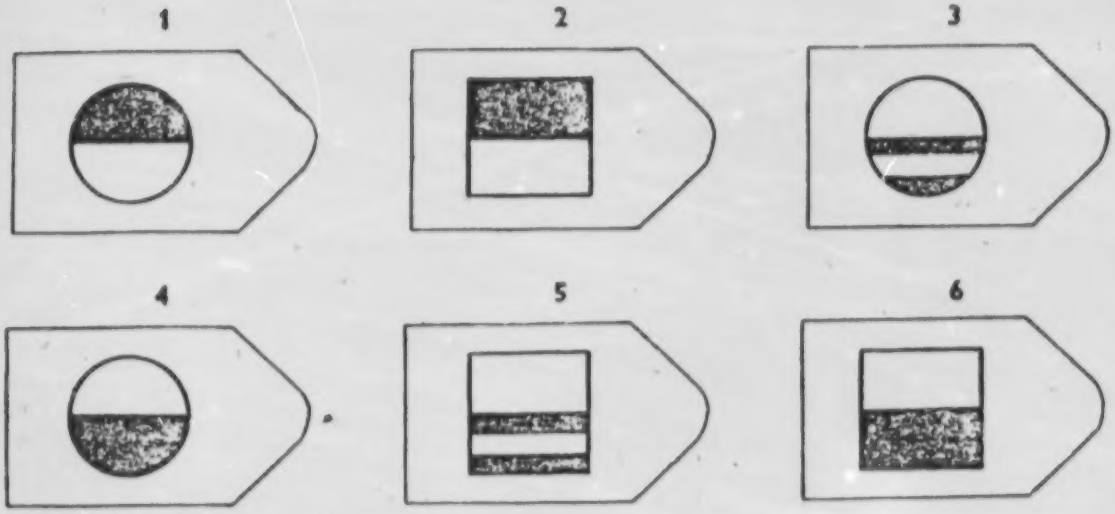

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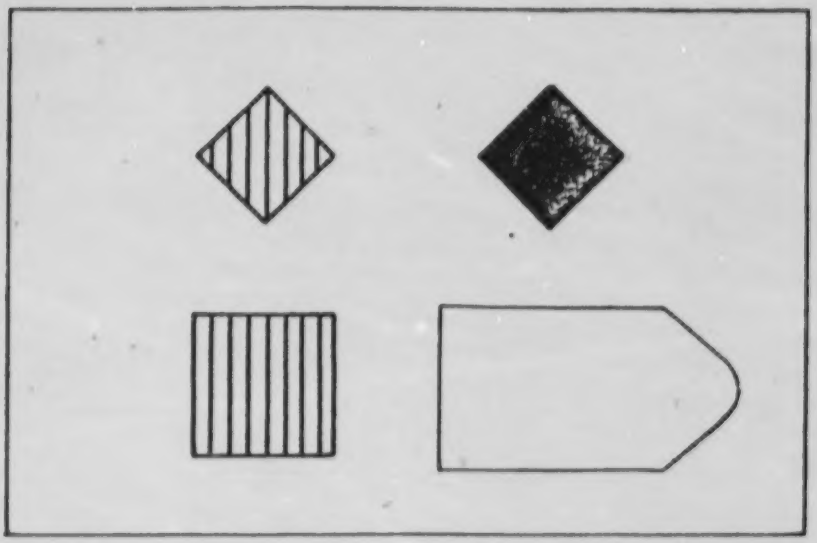

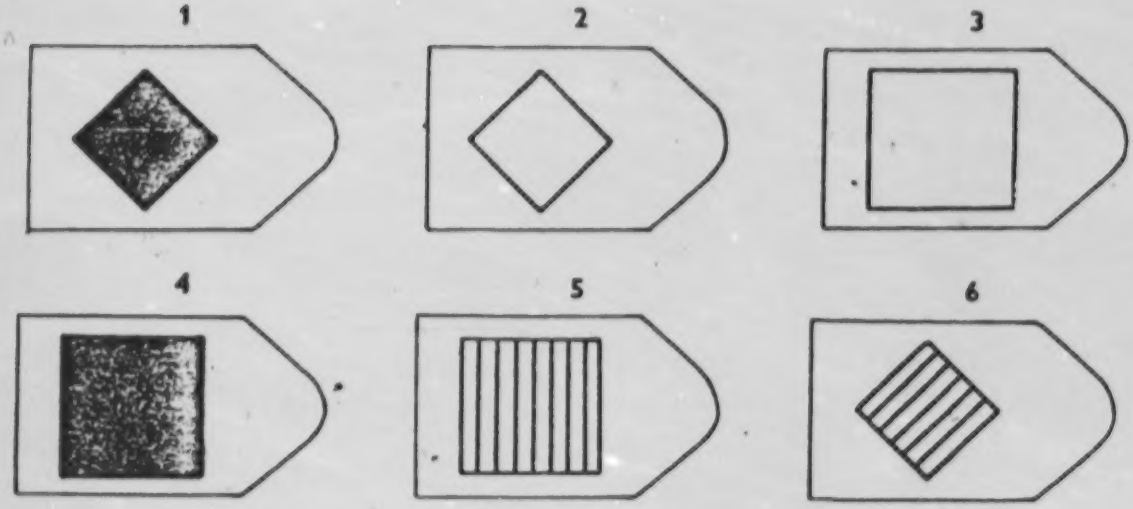

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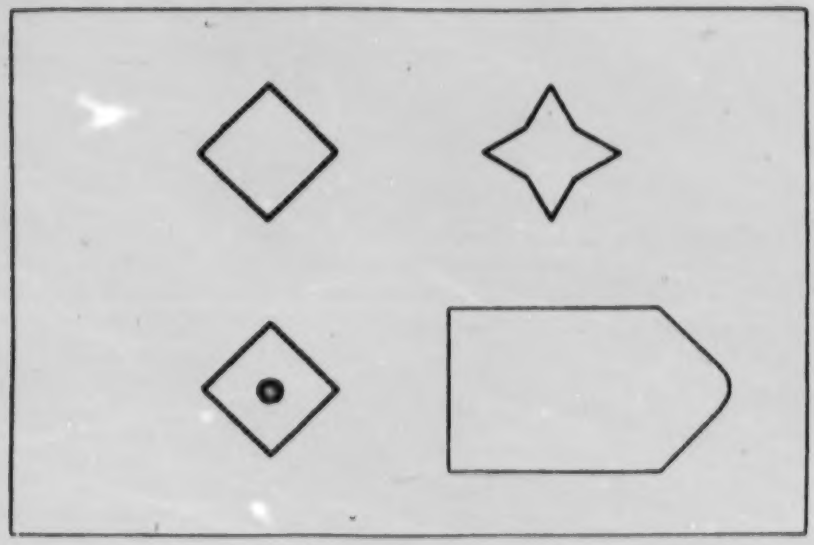

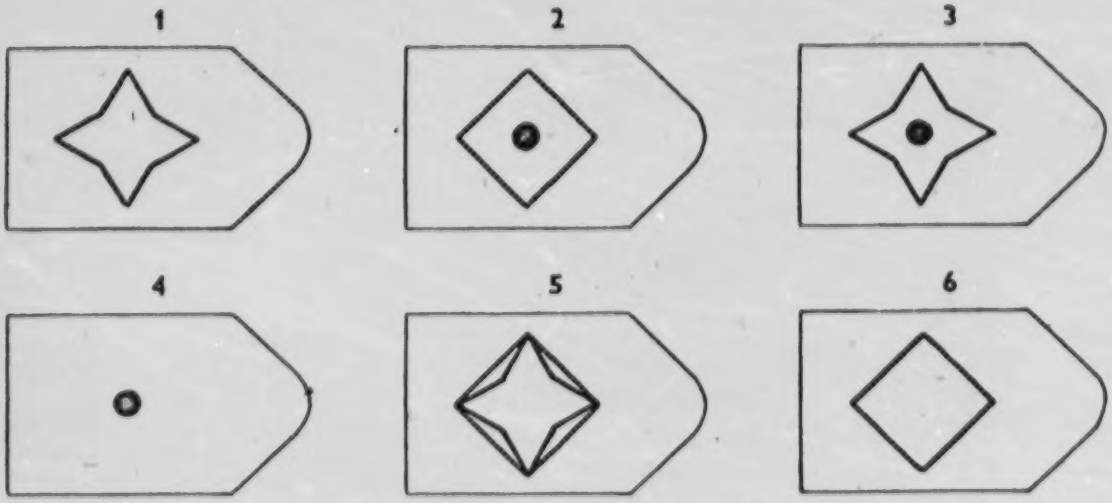

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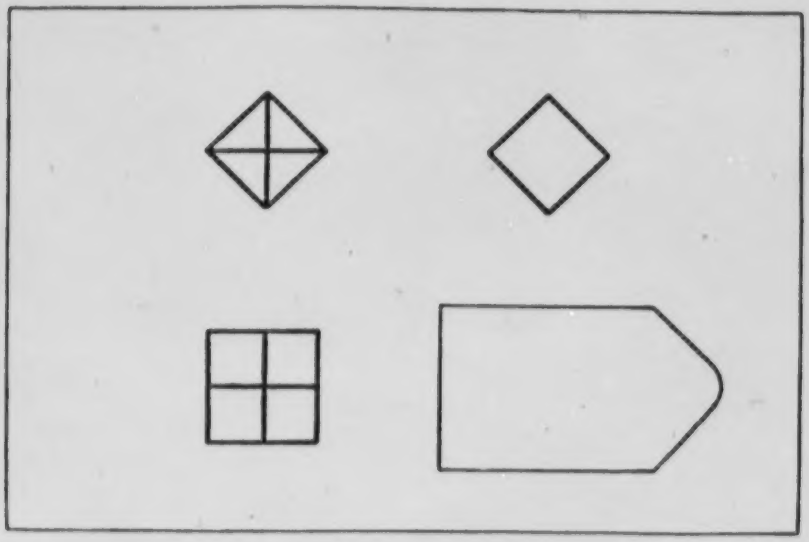

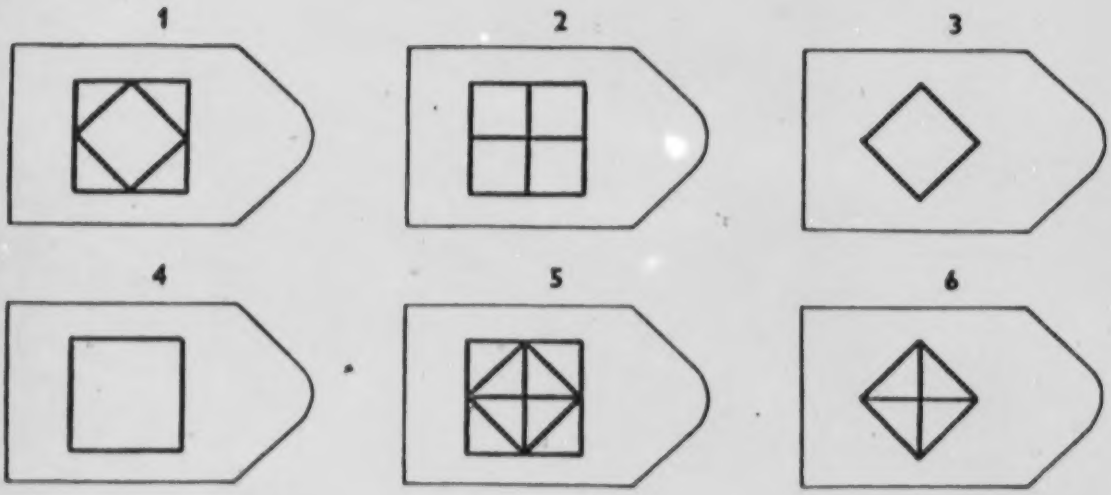

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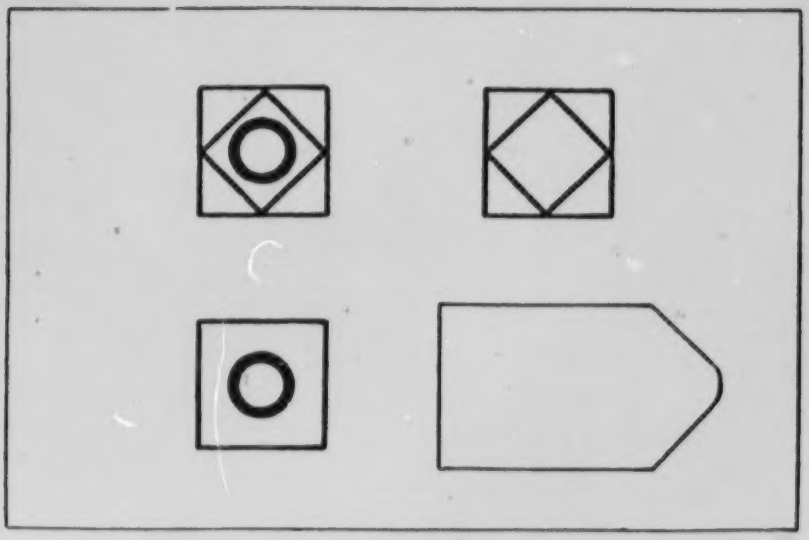

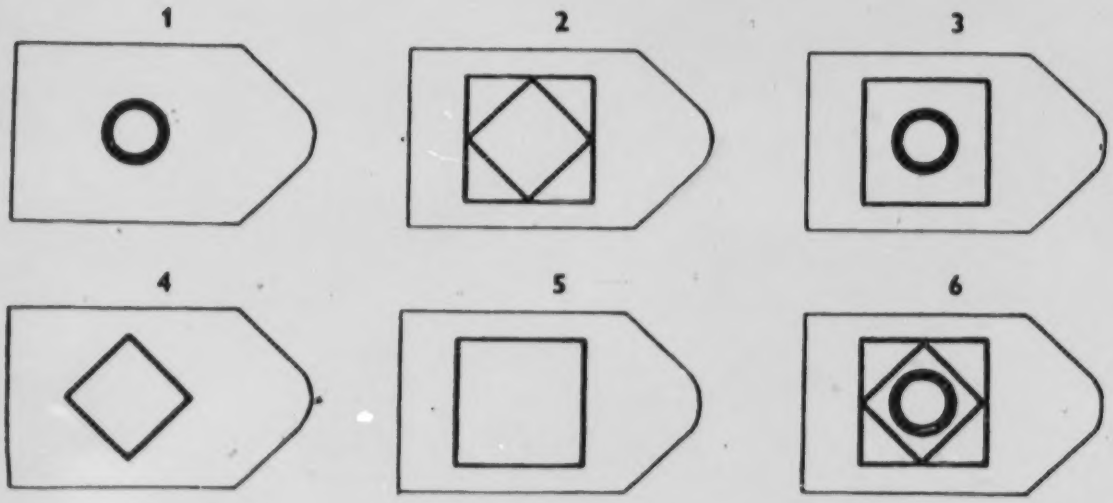

SET C

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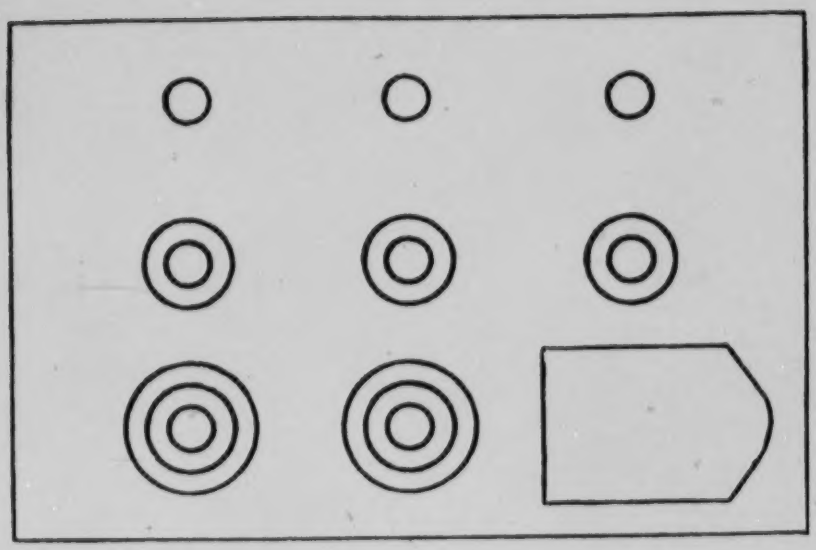

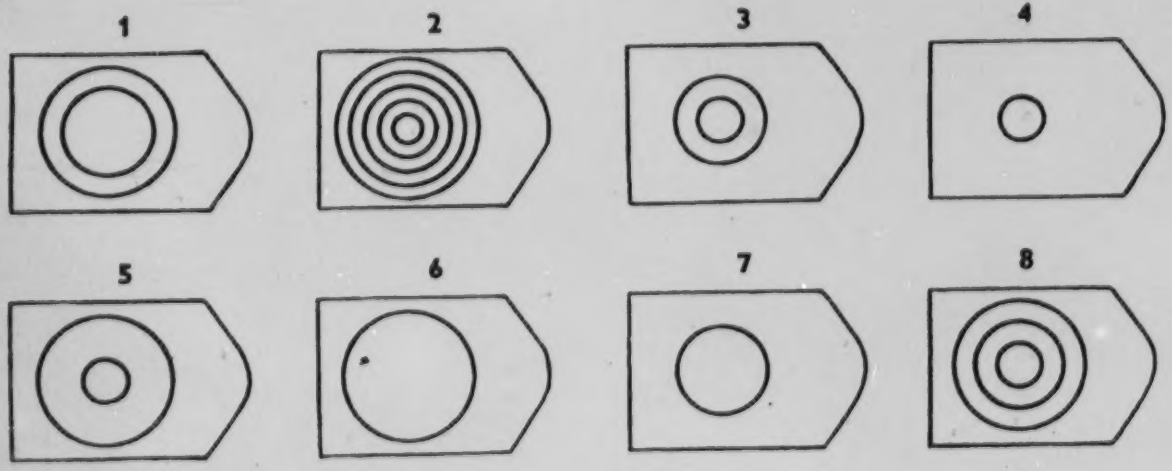

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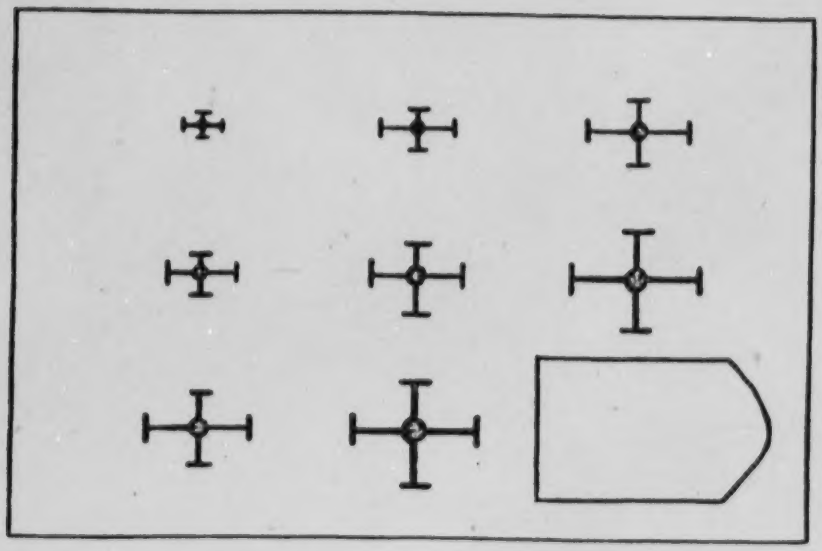

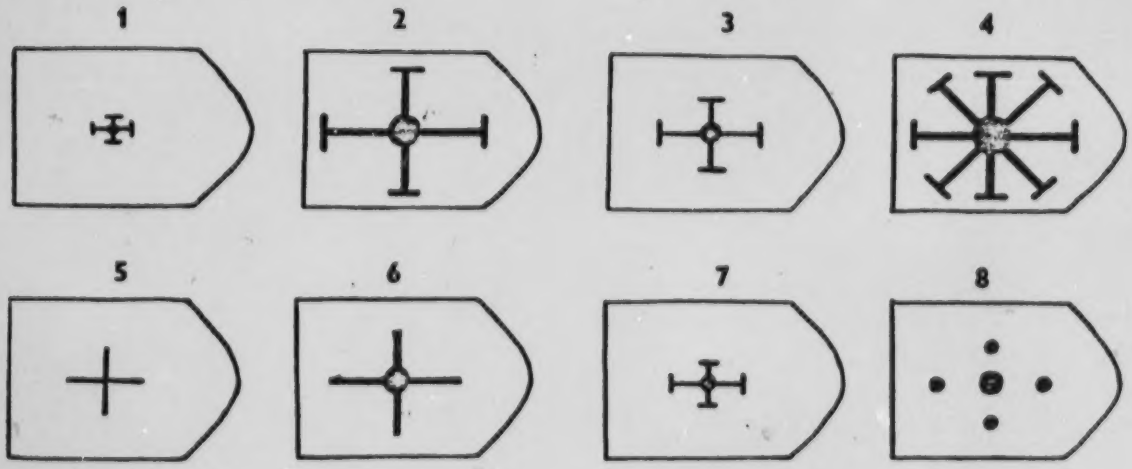

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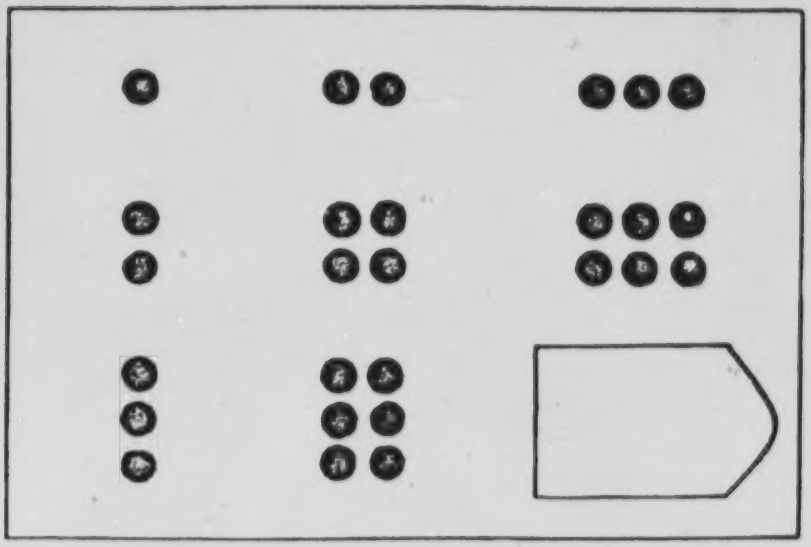

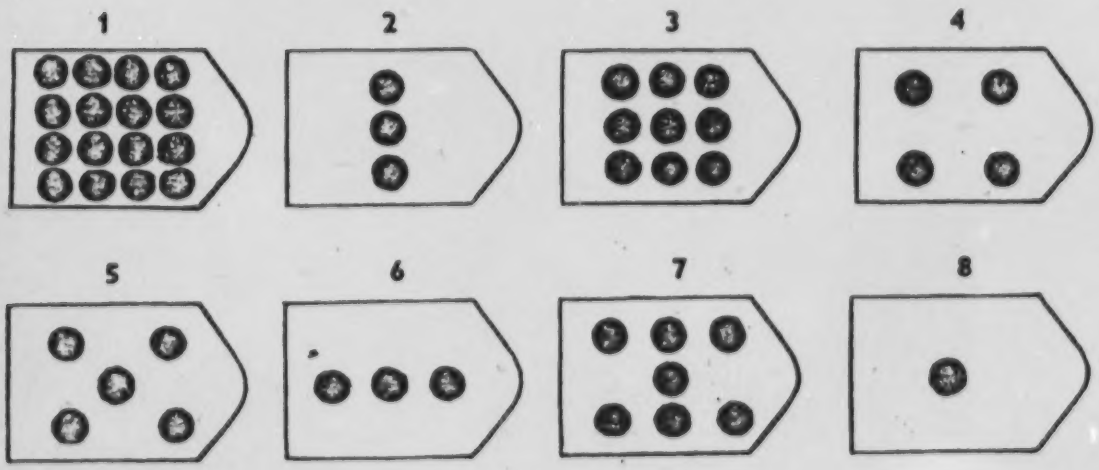

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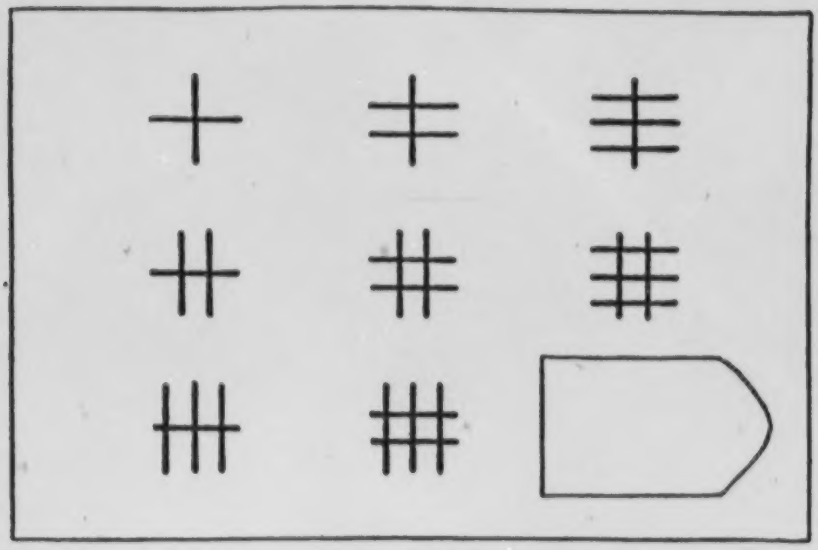

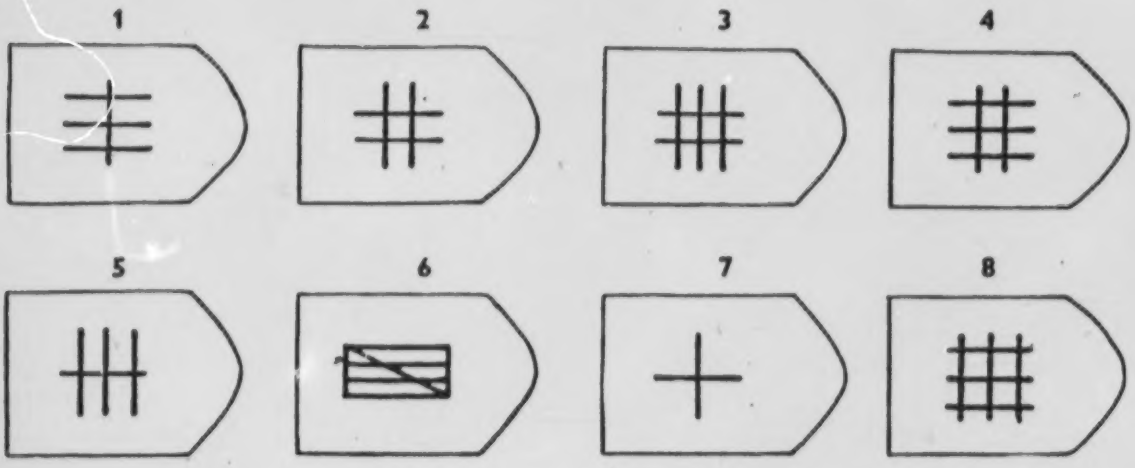

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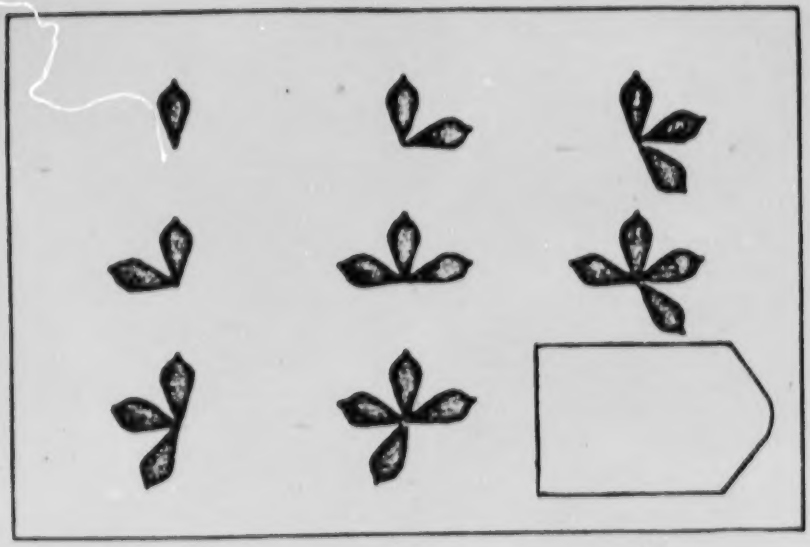

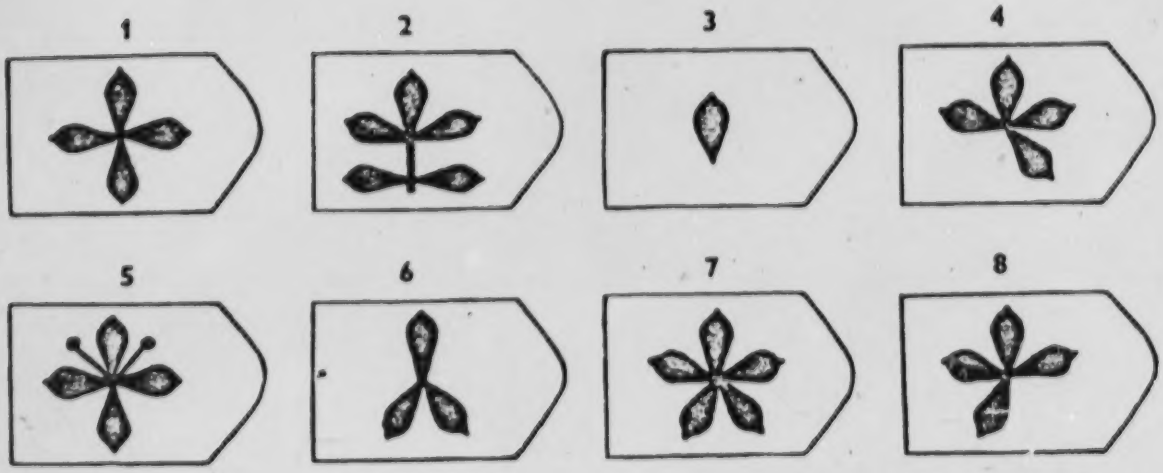

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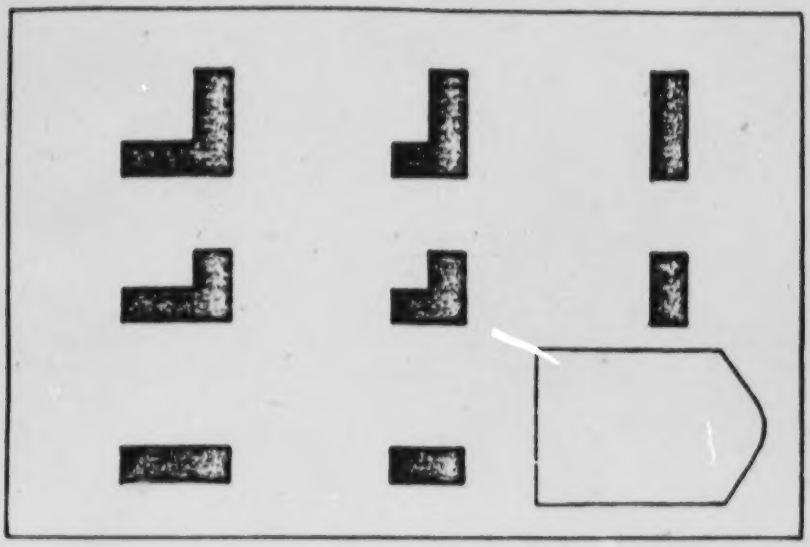

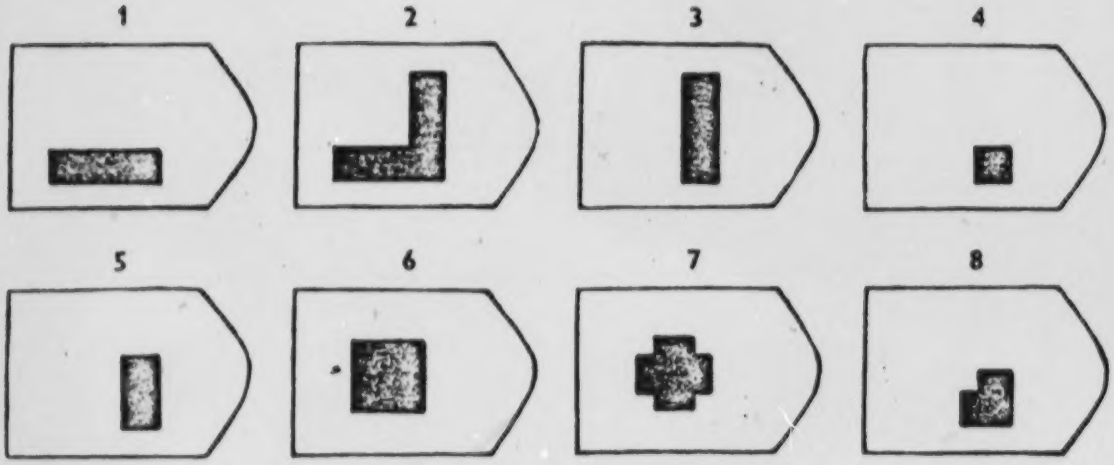

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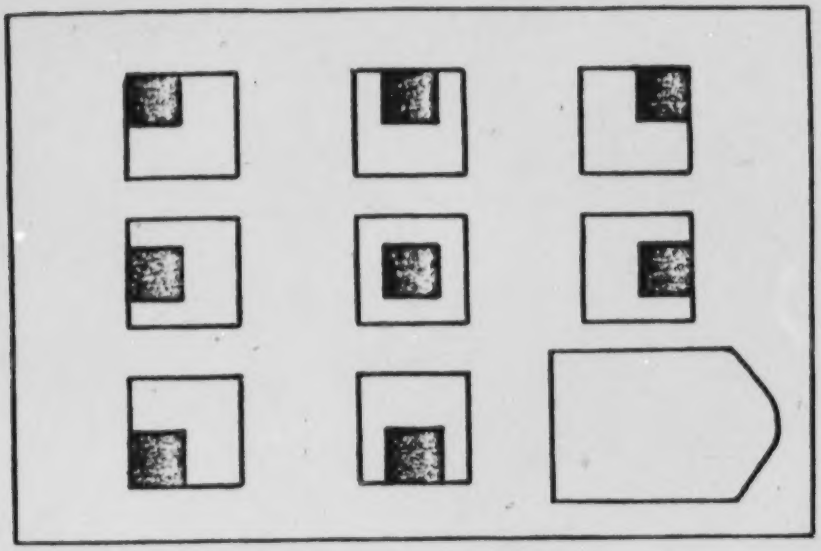

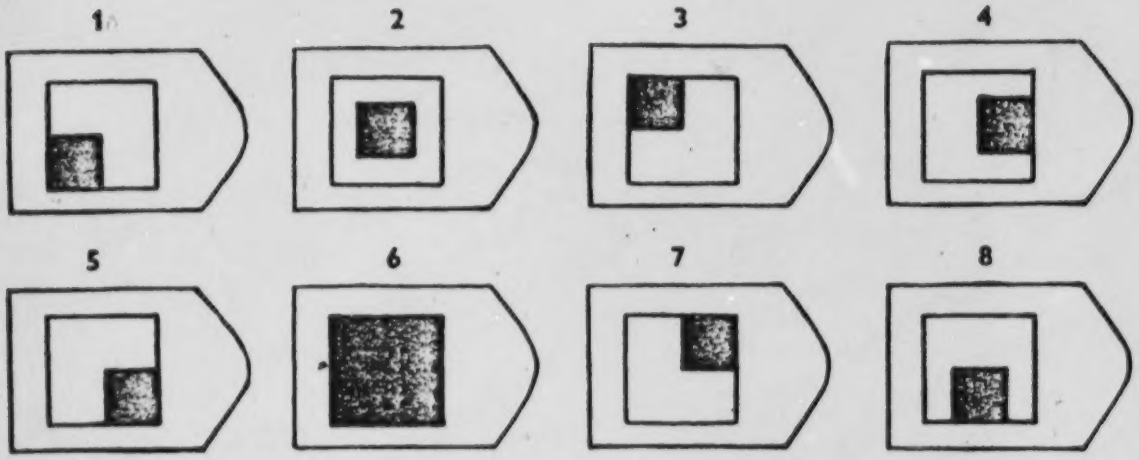

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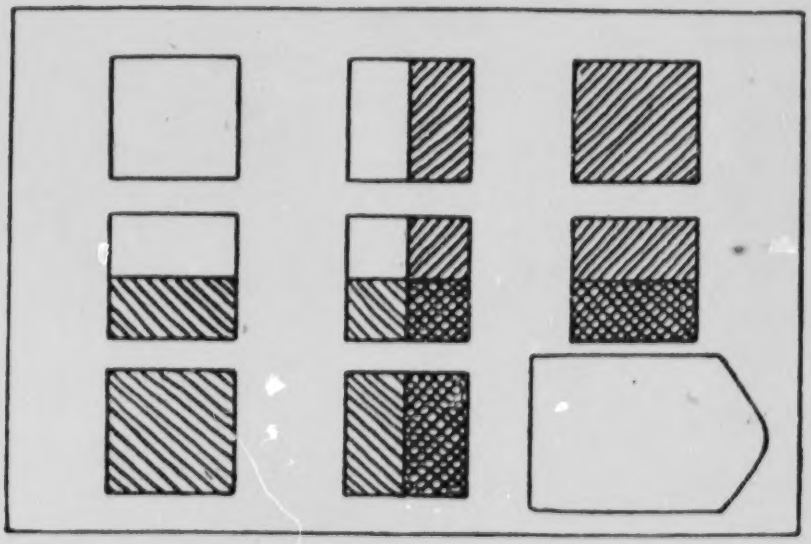

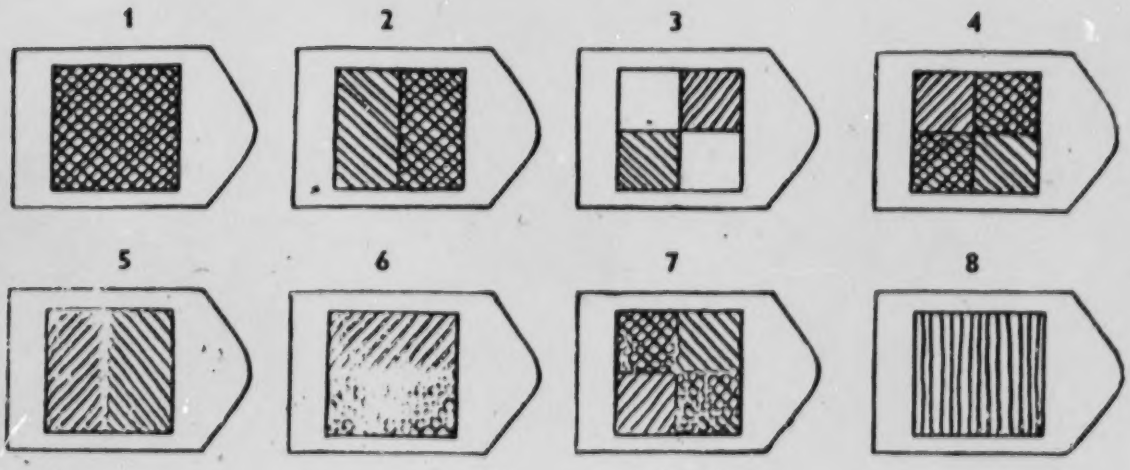

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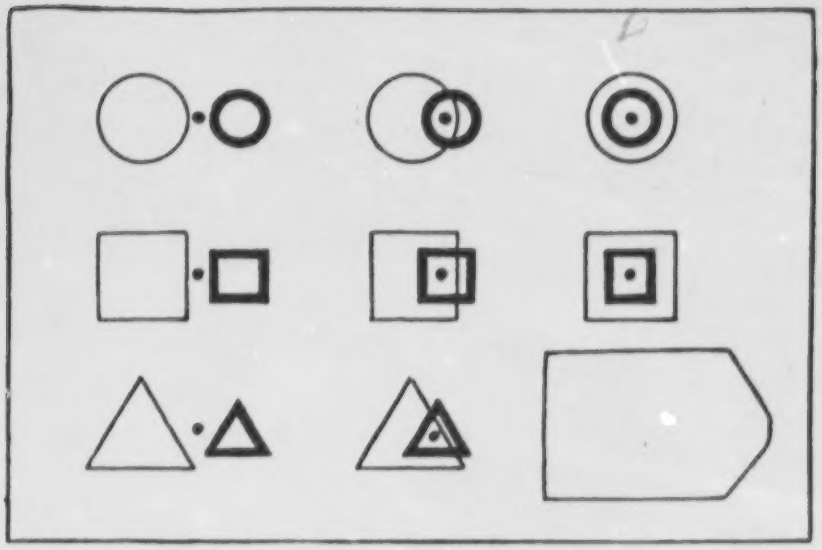

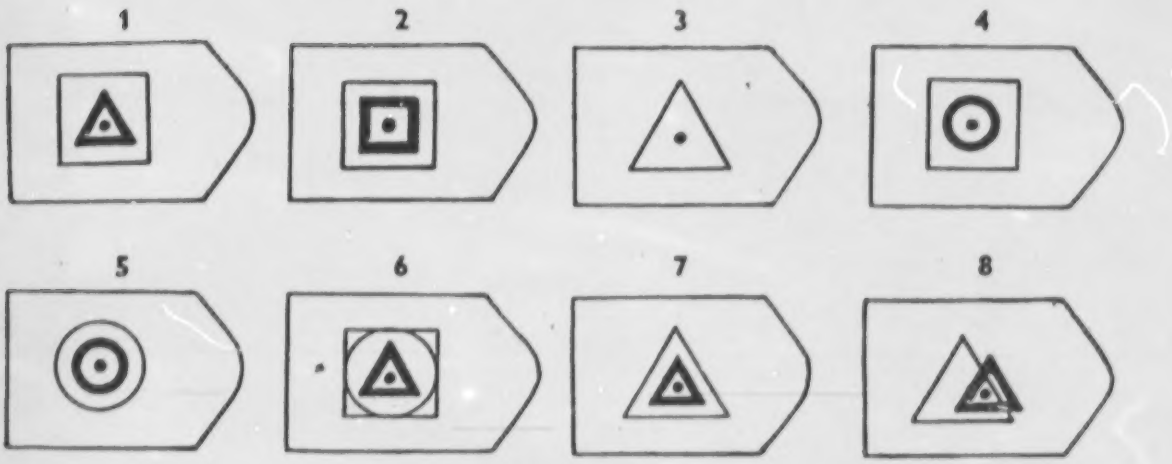

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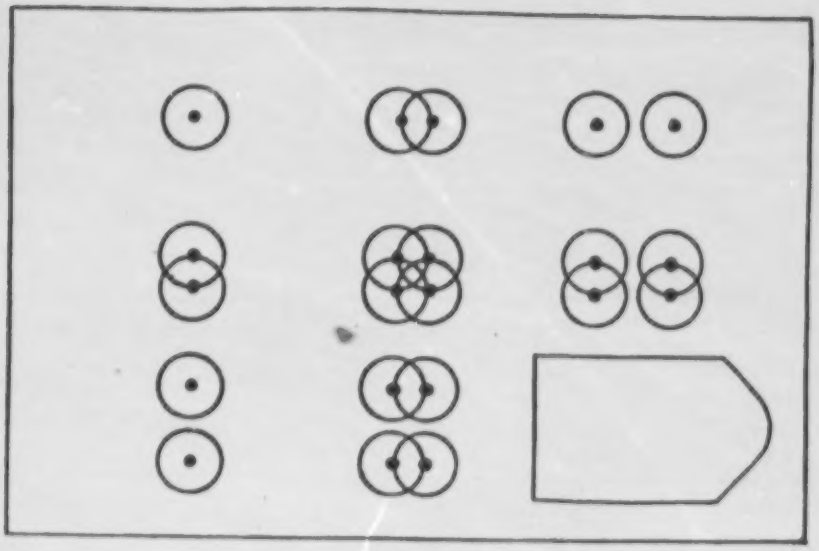

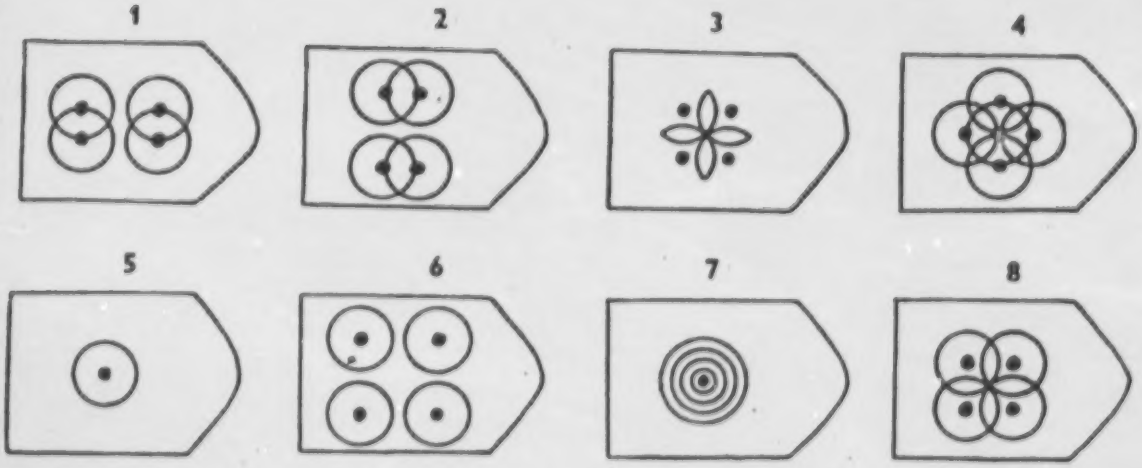

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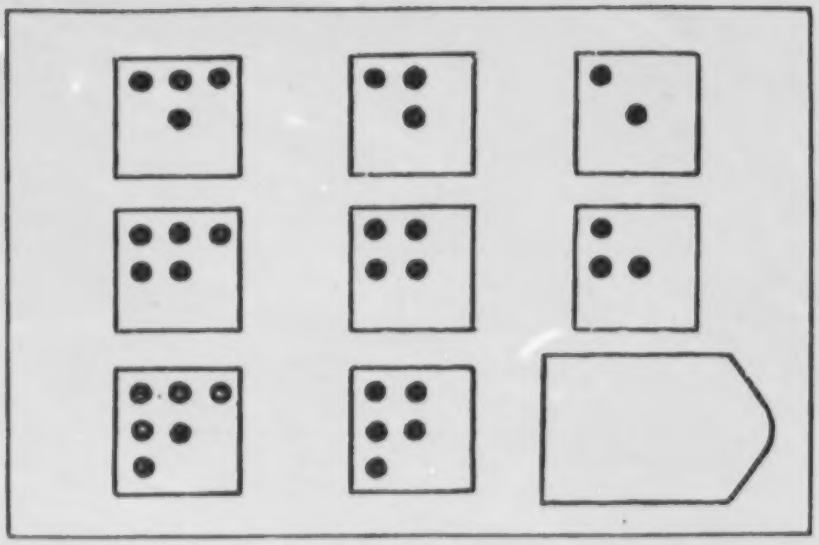

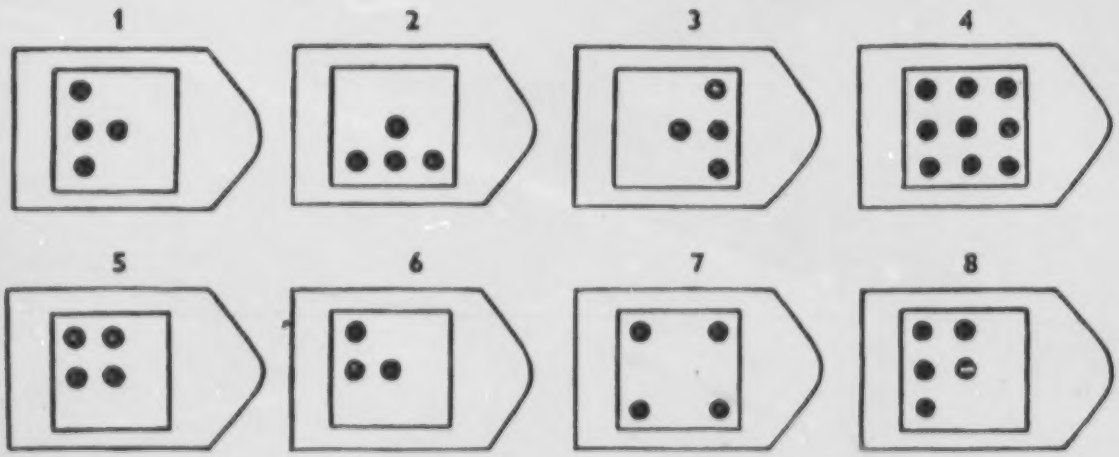

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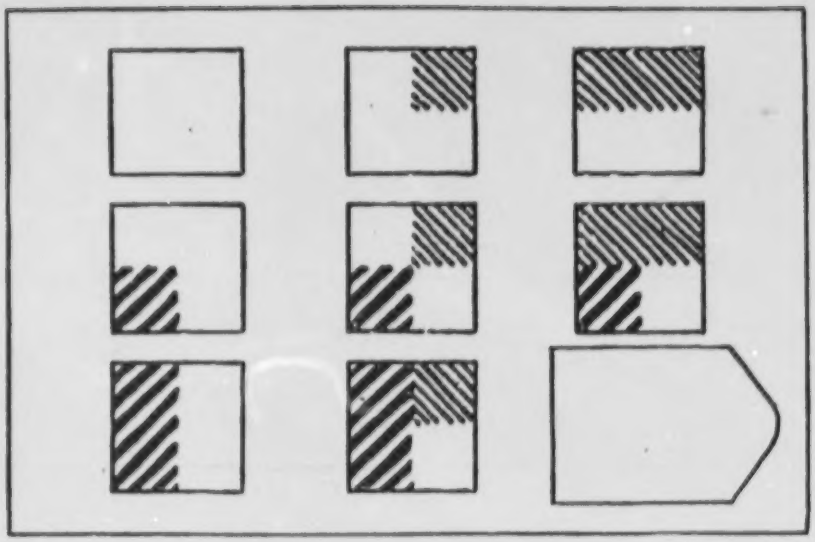

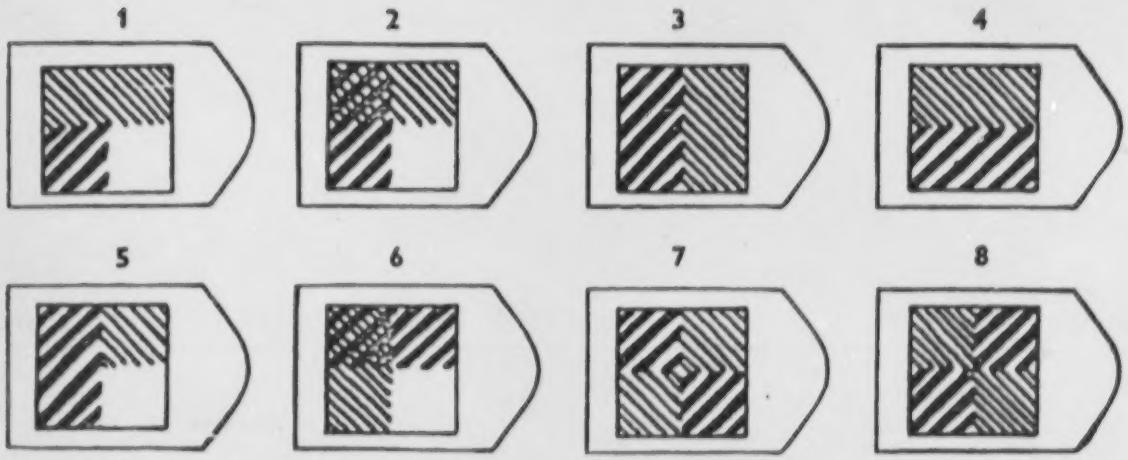

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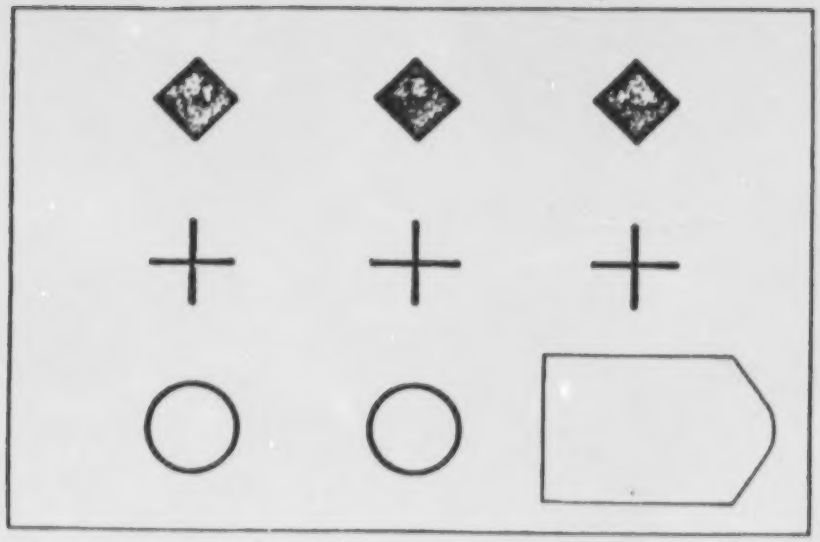

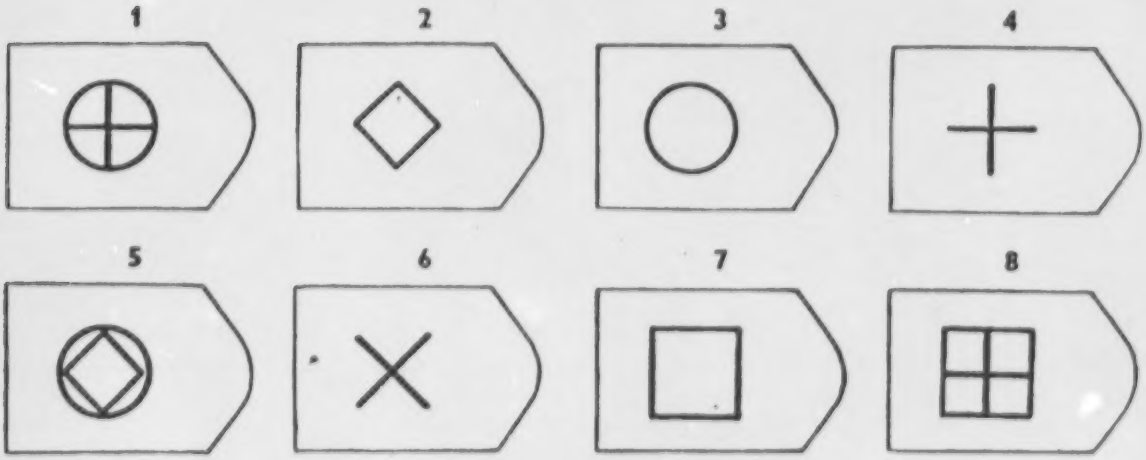

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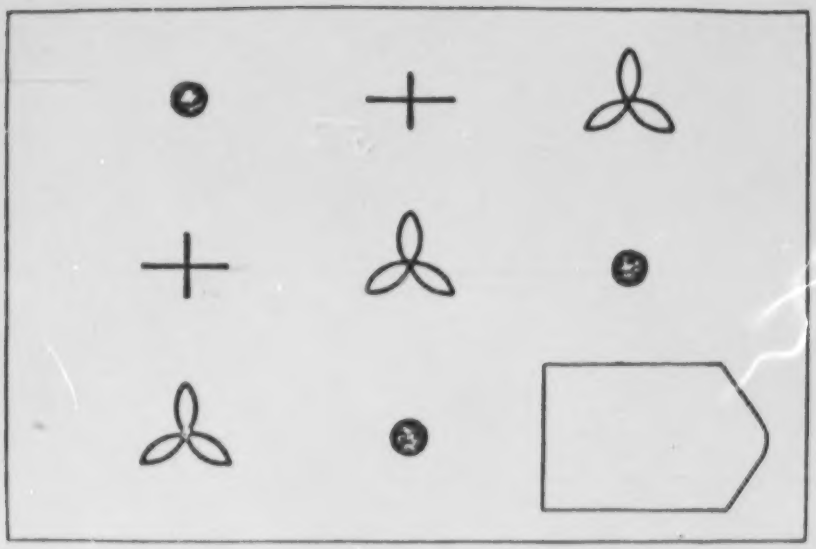

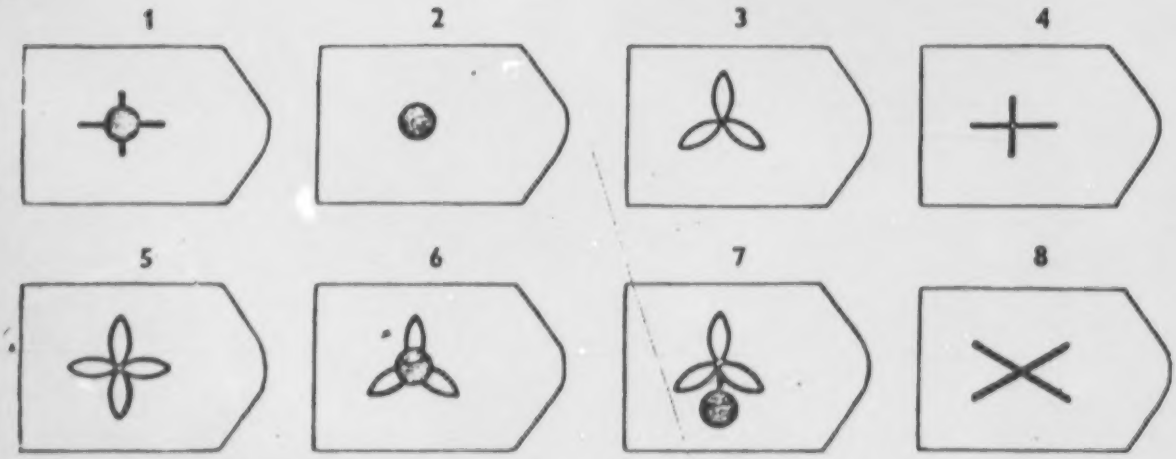

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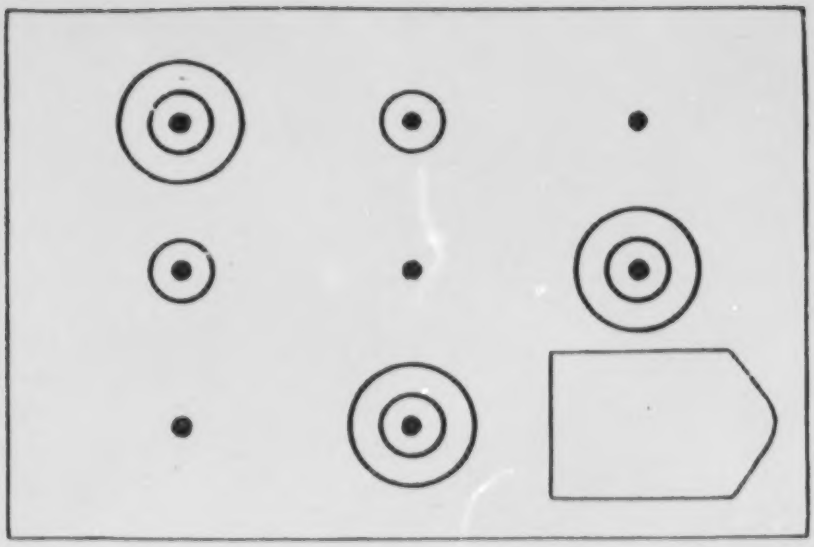

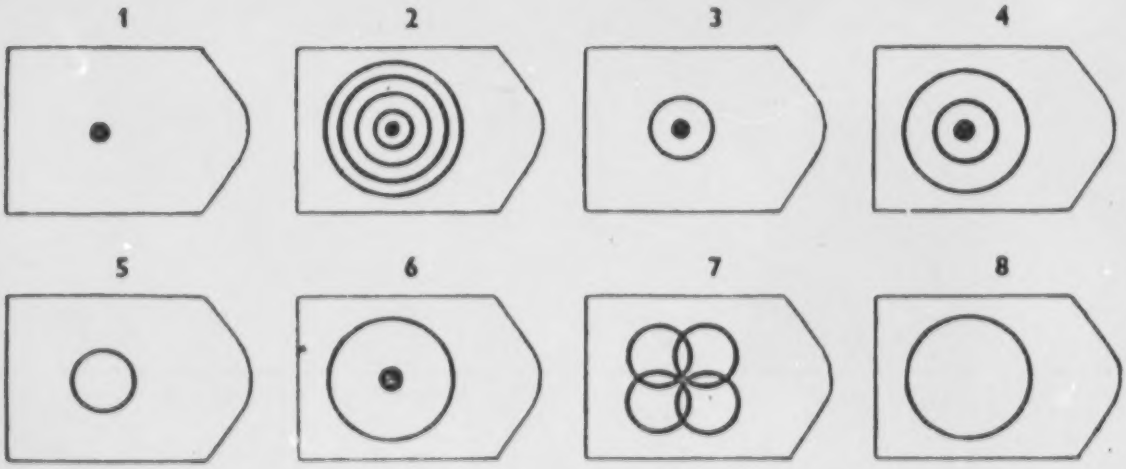

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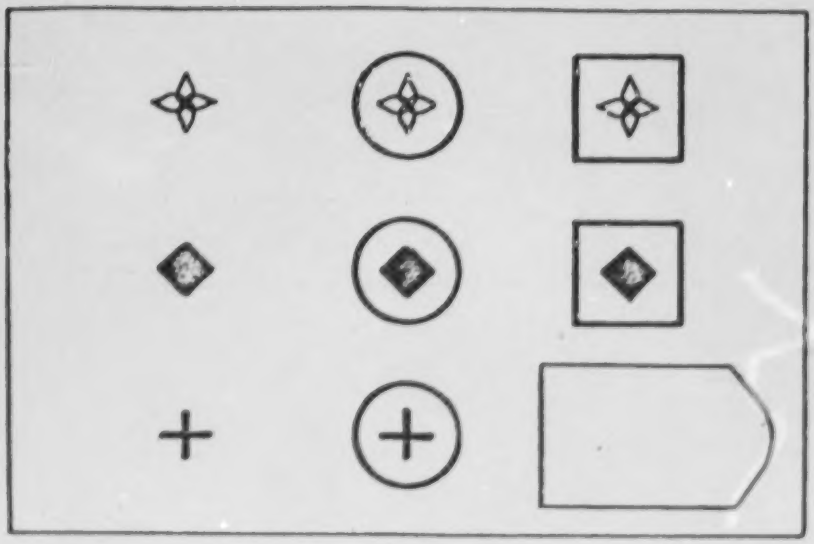

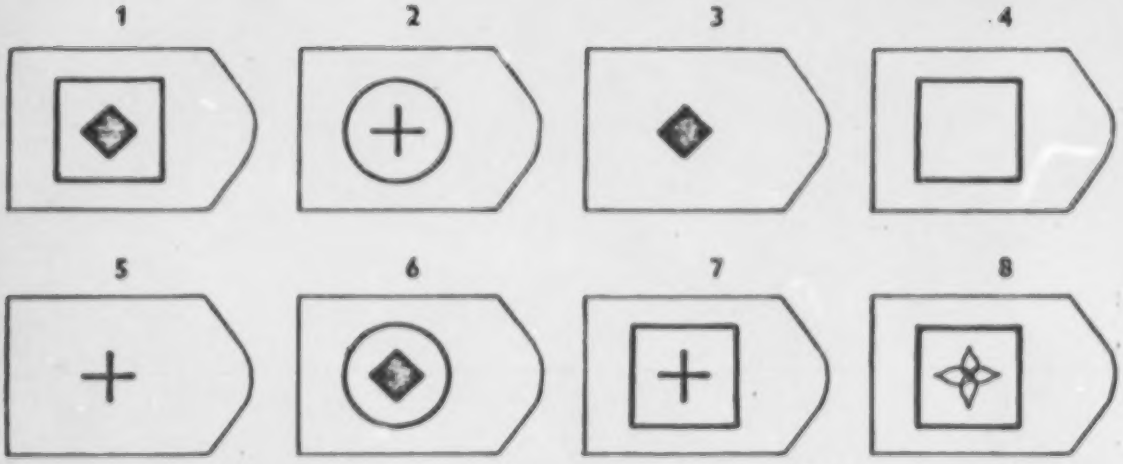

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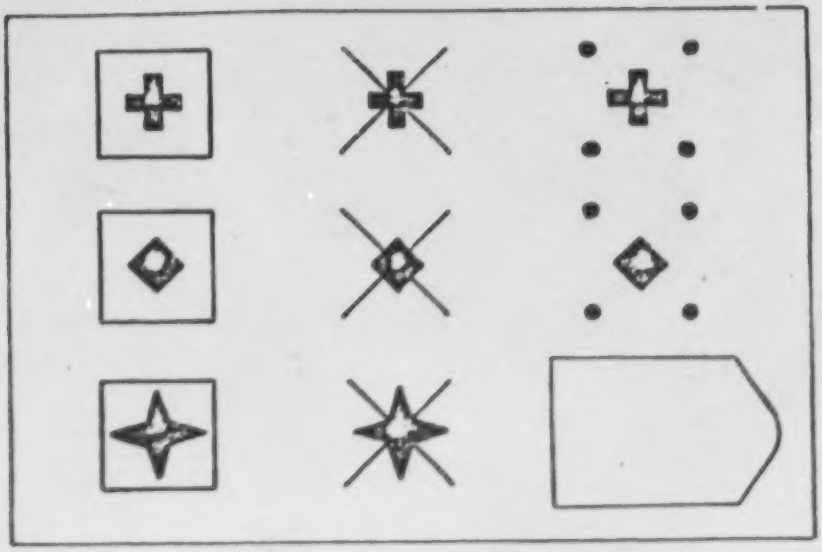

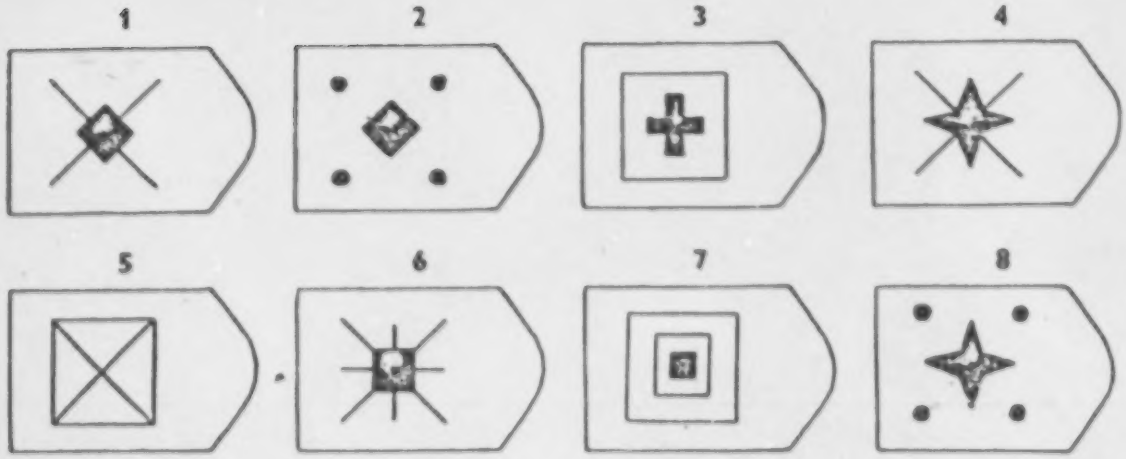

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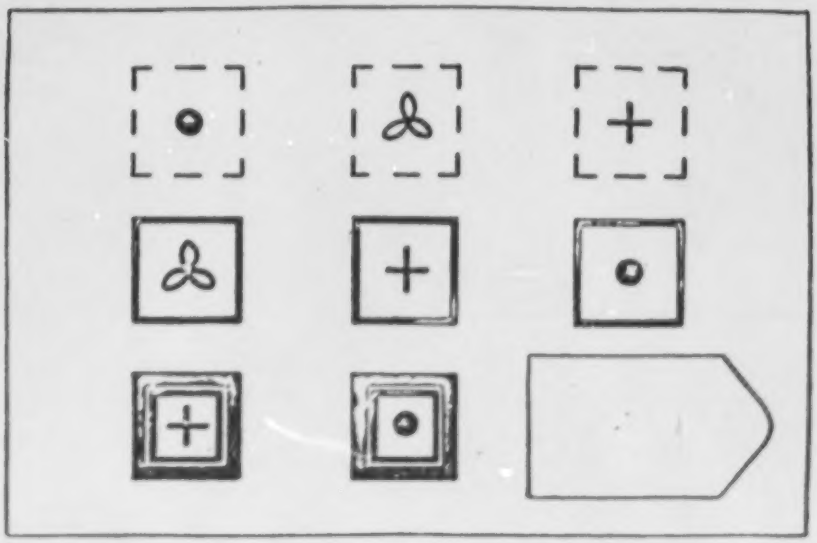

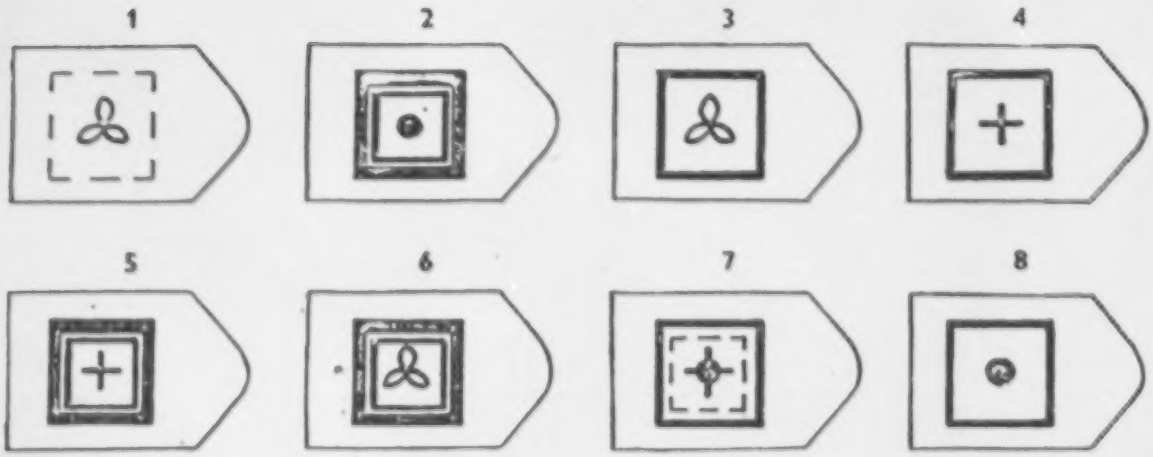

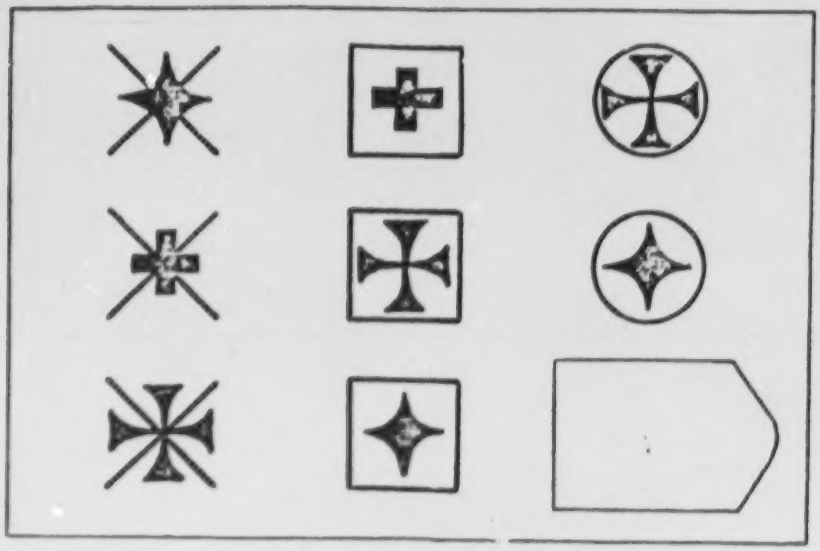

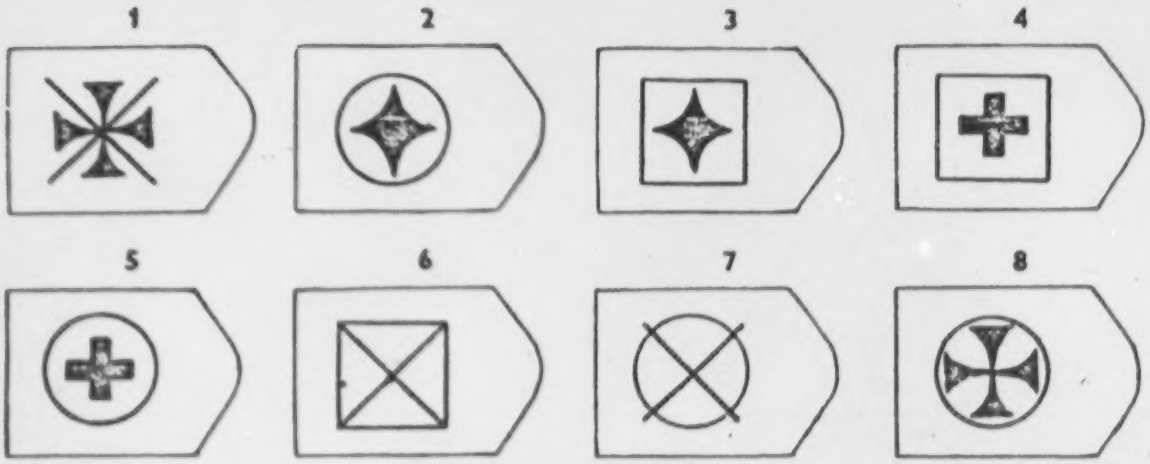
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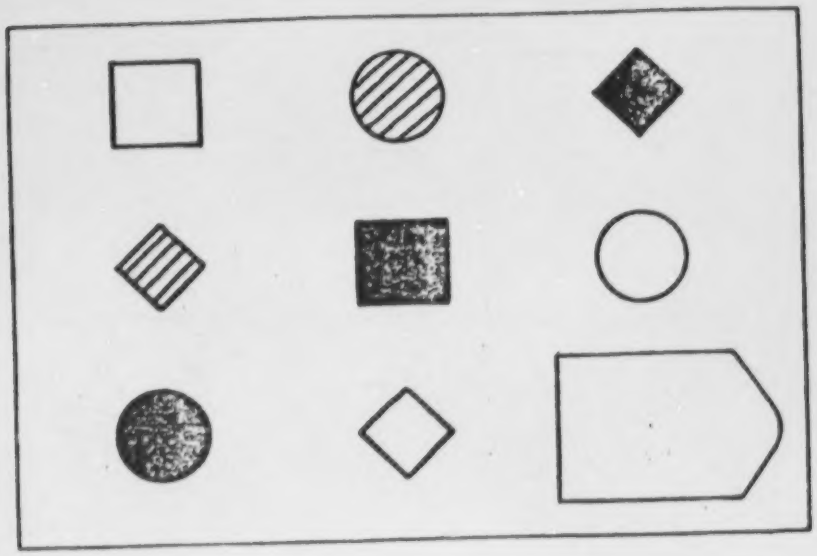
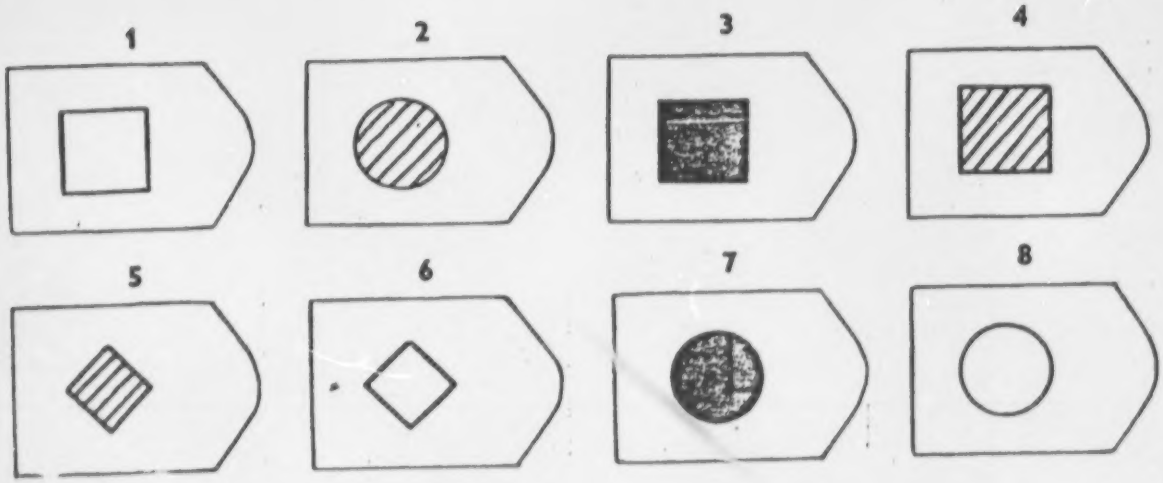
D 8





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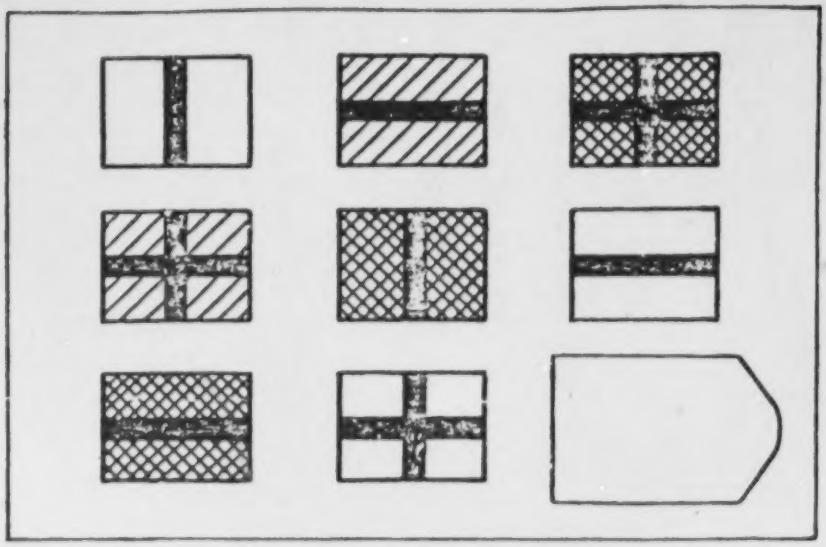

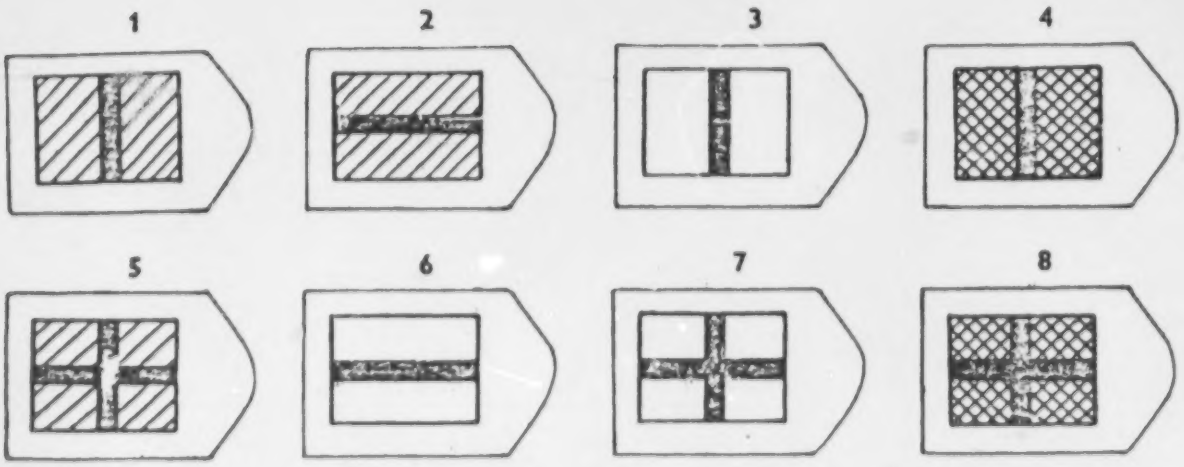

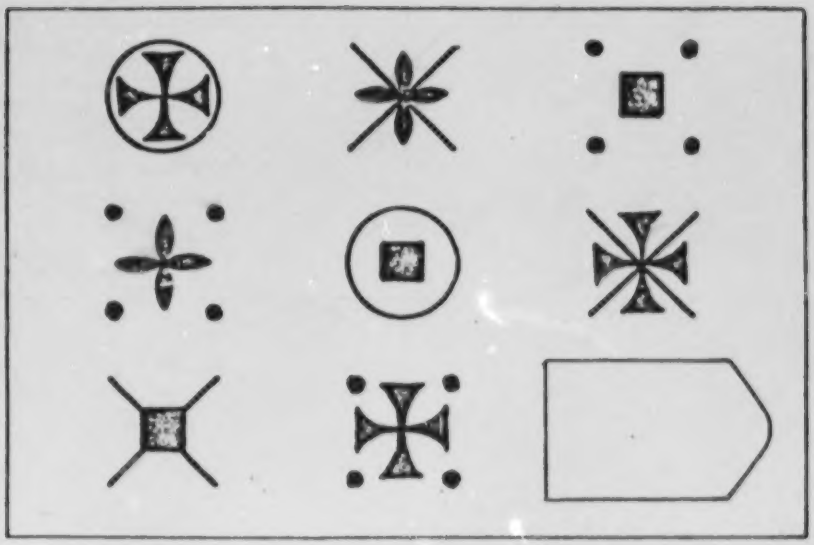

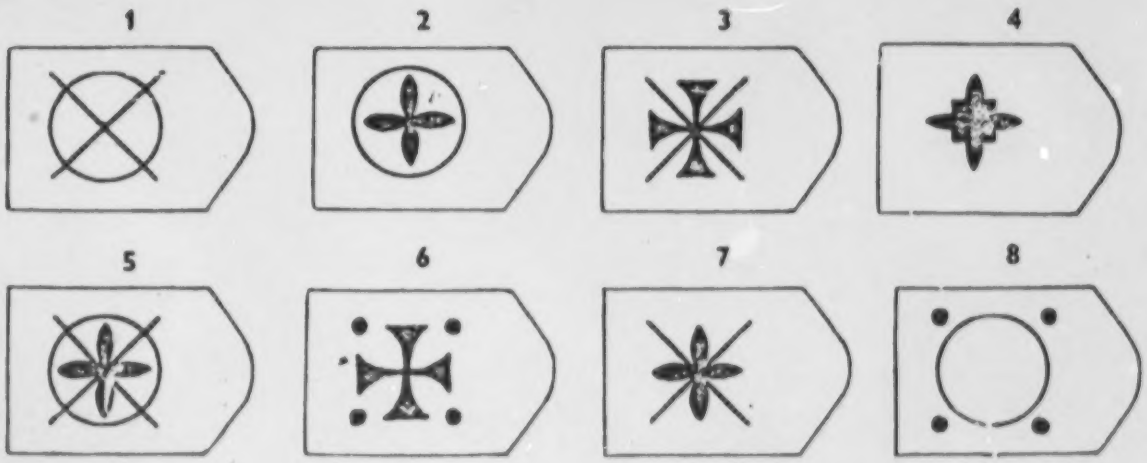
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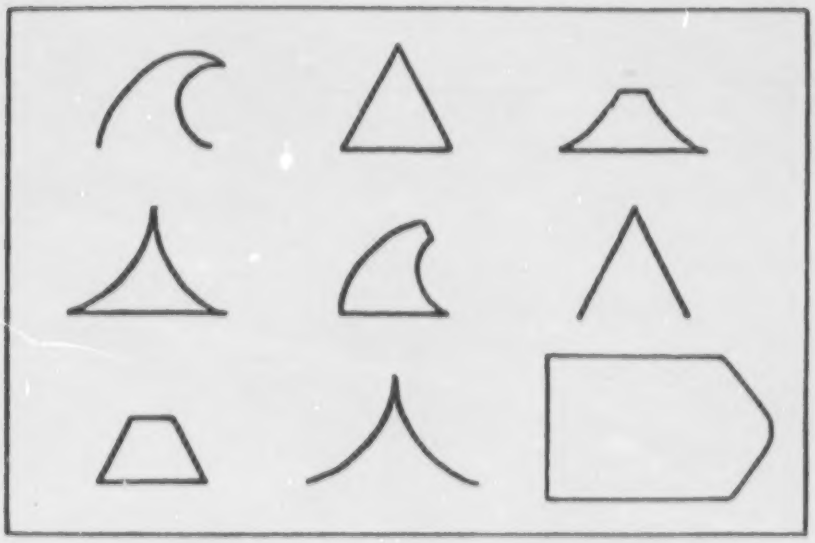
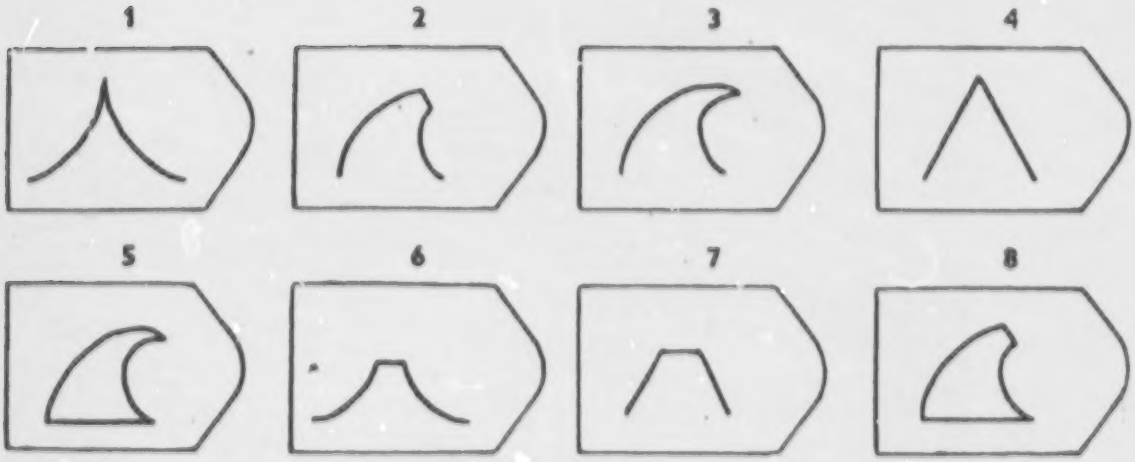
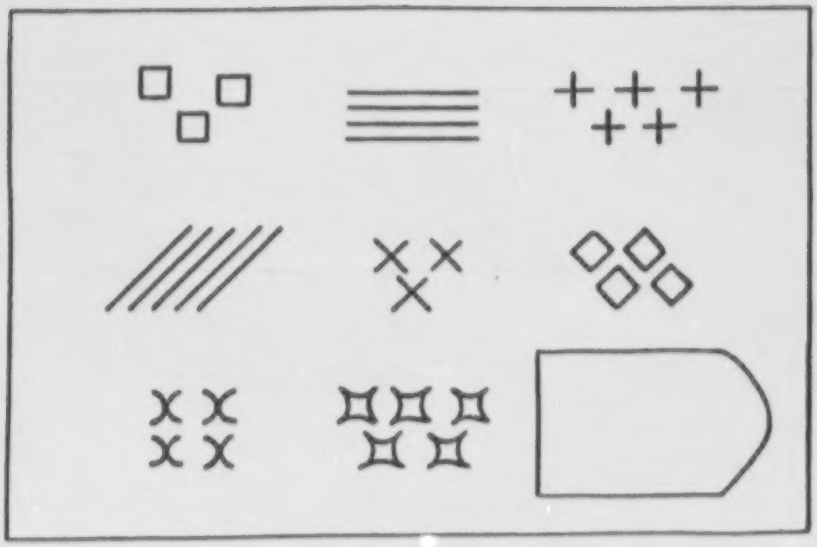
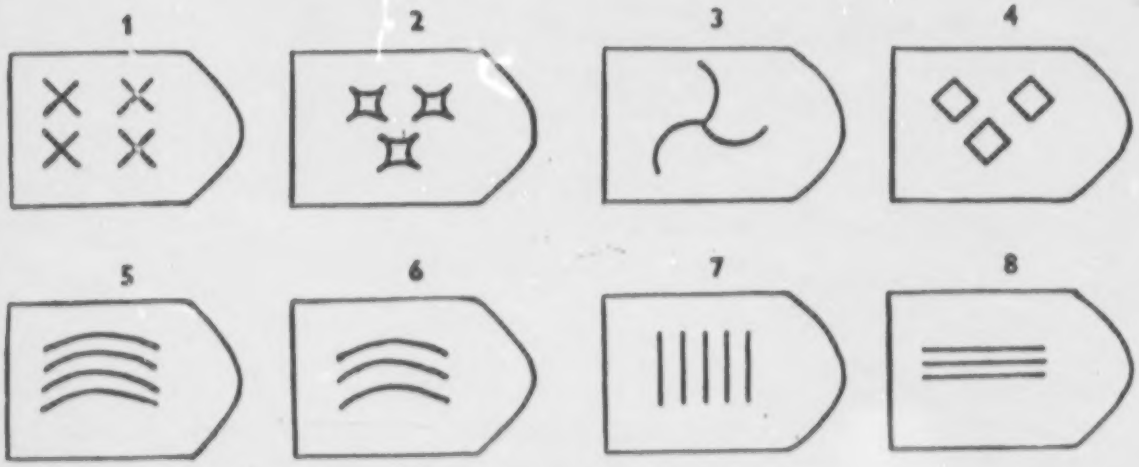
D II





D 12





SET E

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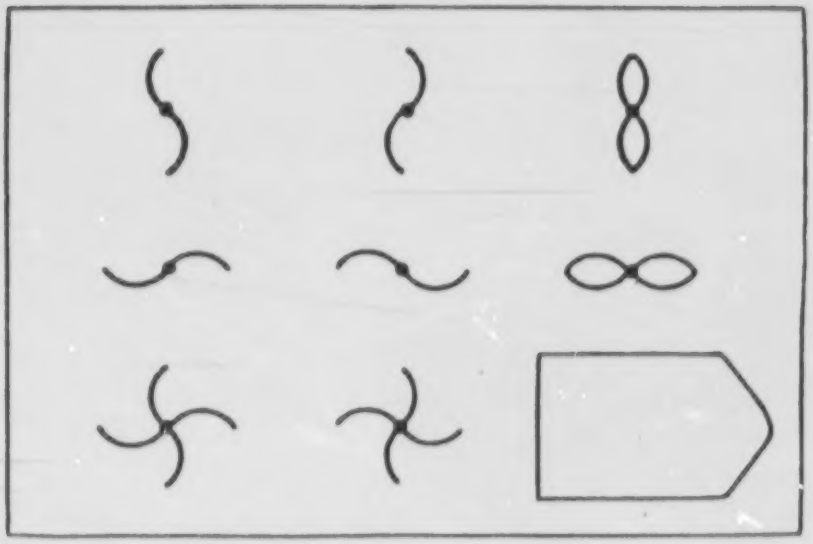

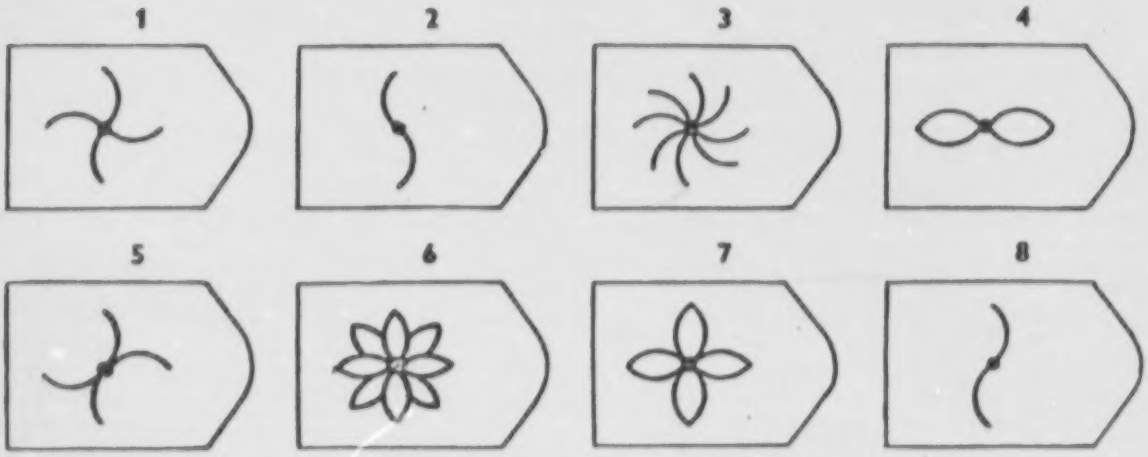

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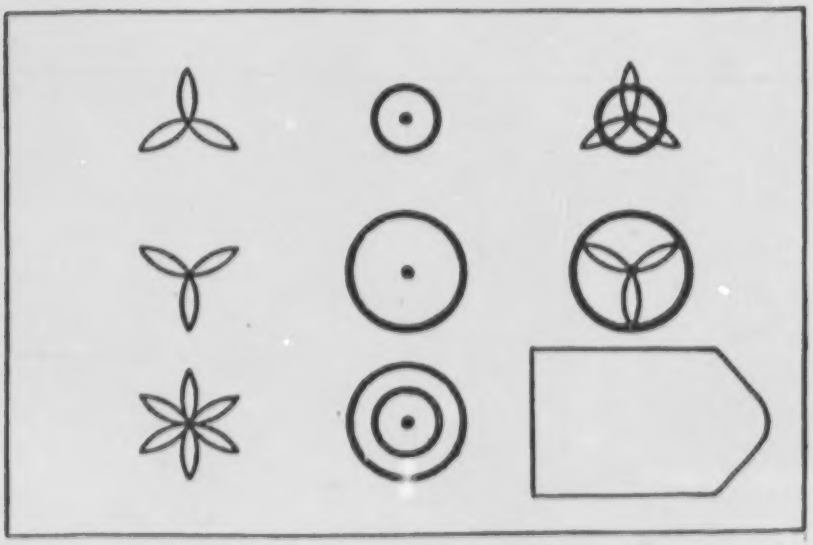

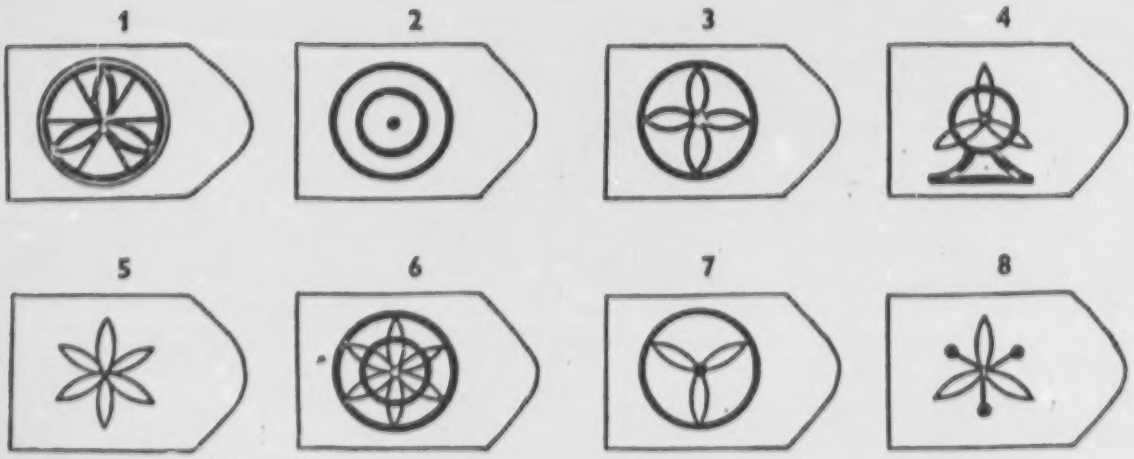

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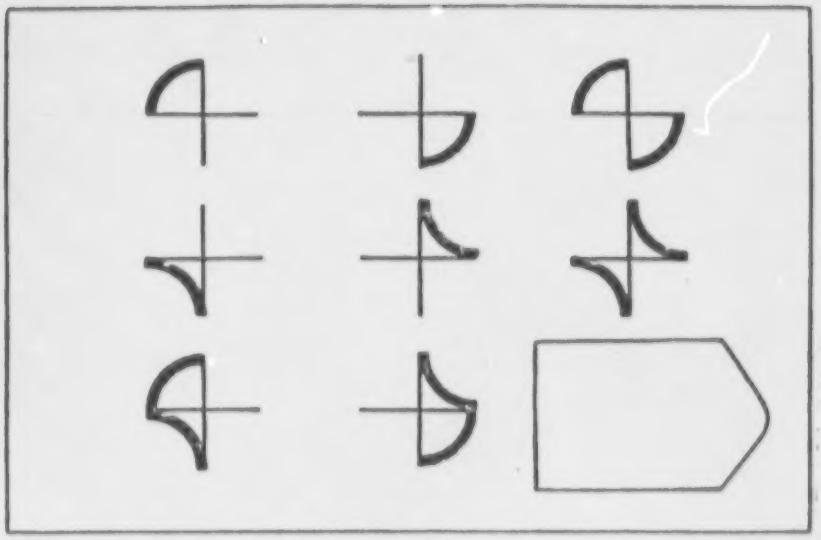

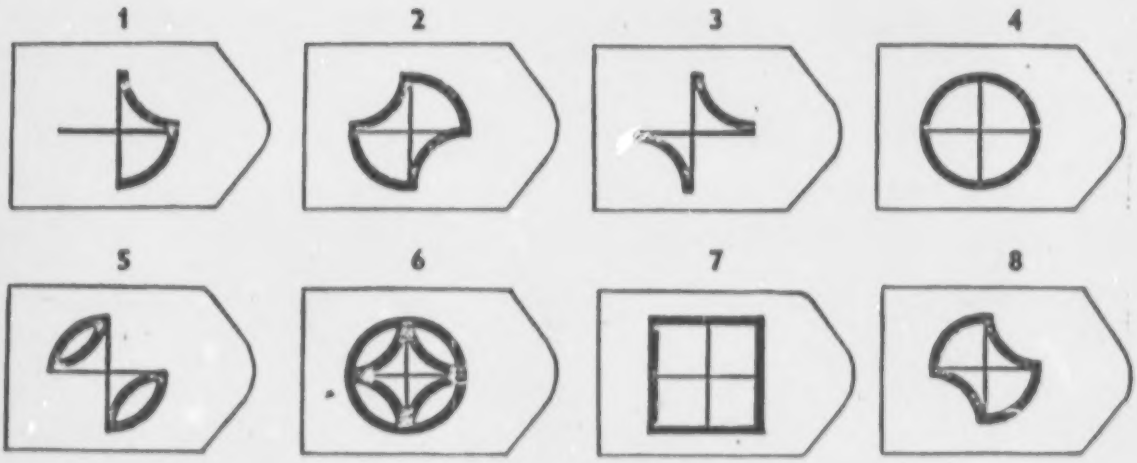

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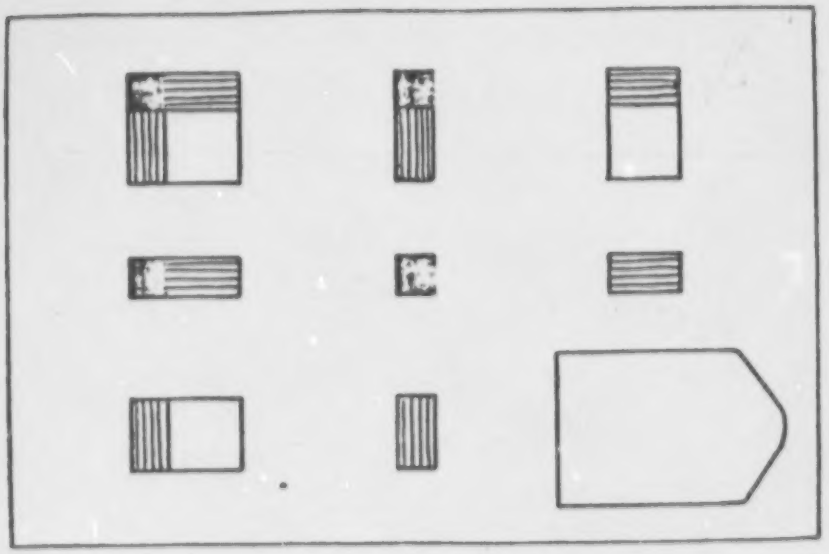

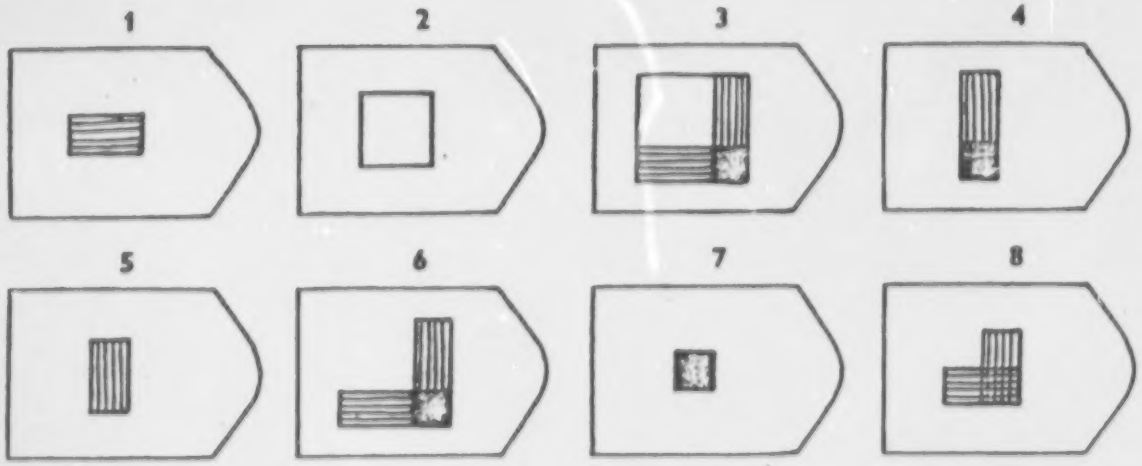

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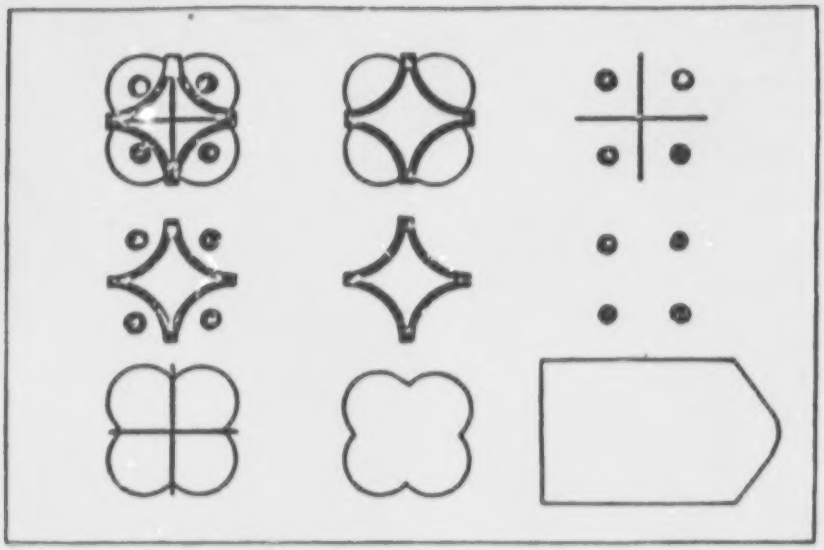

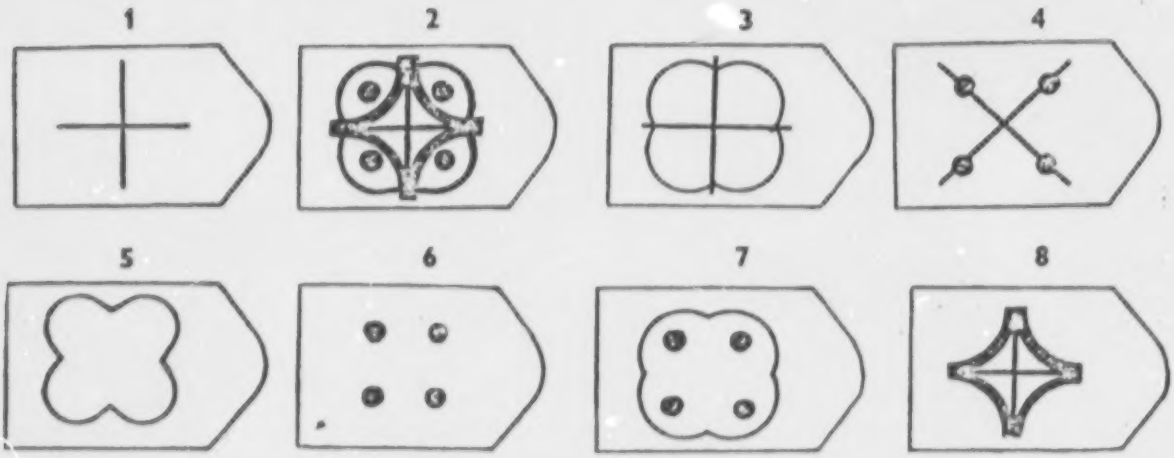

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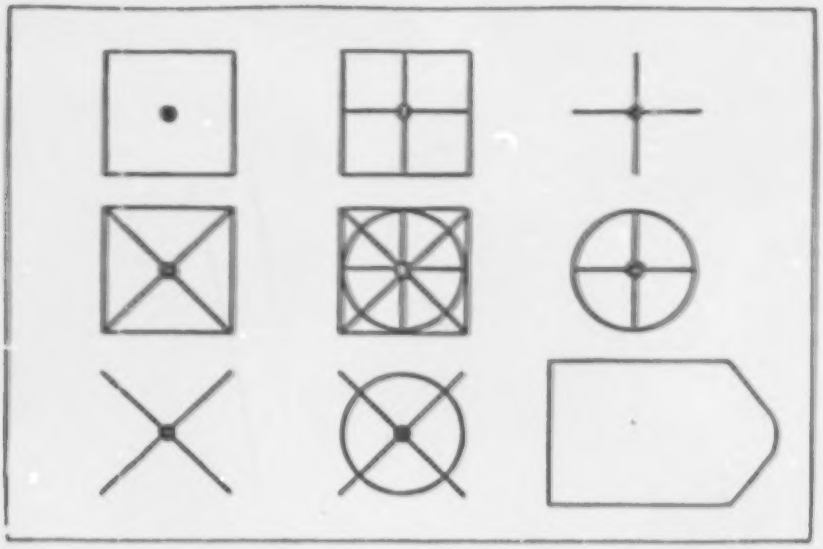

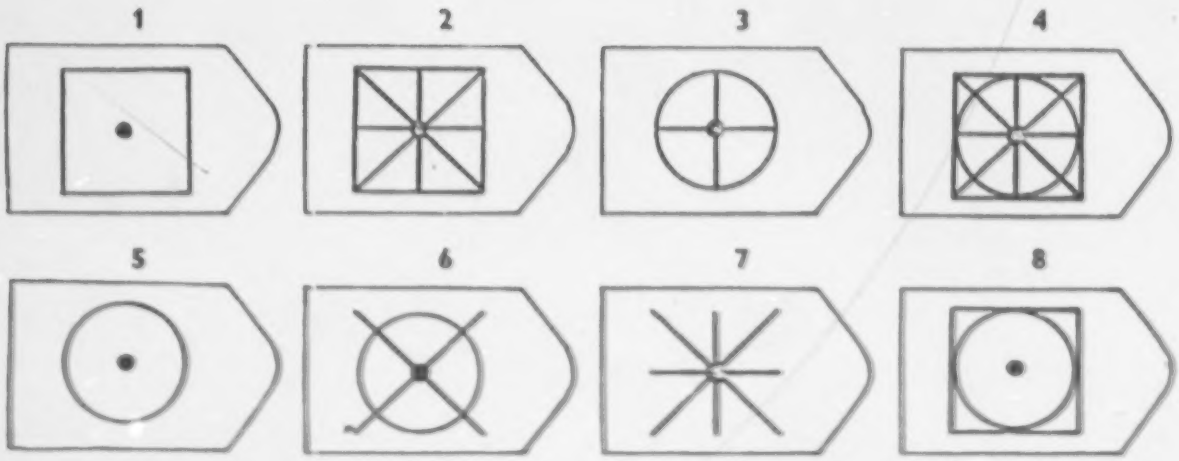

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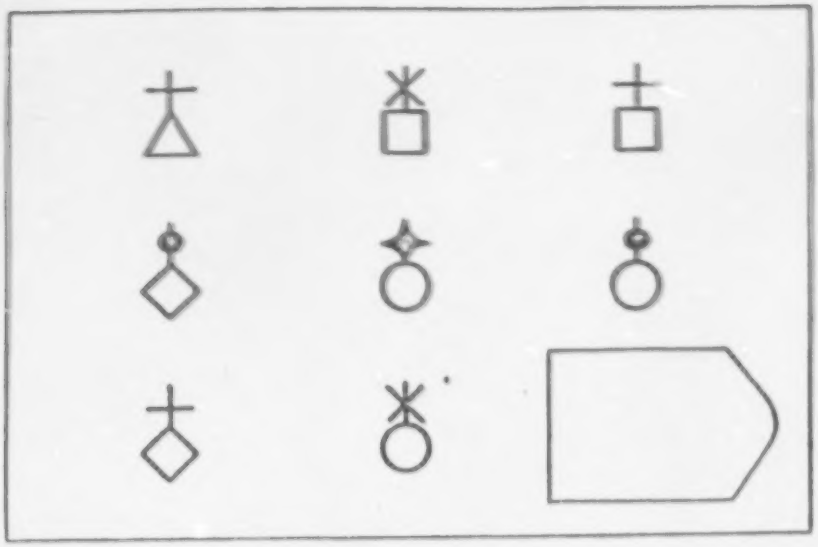

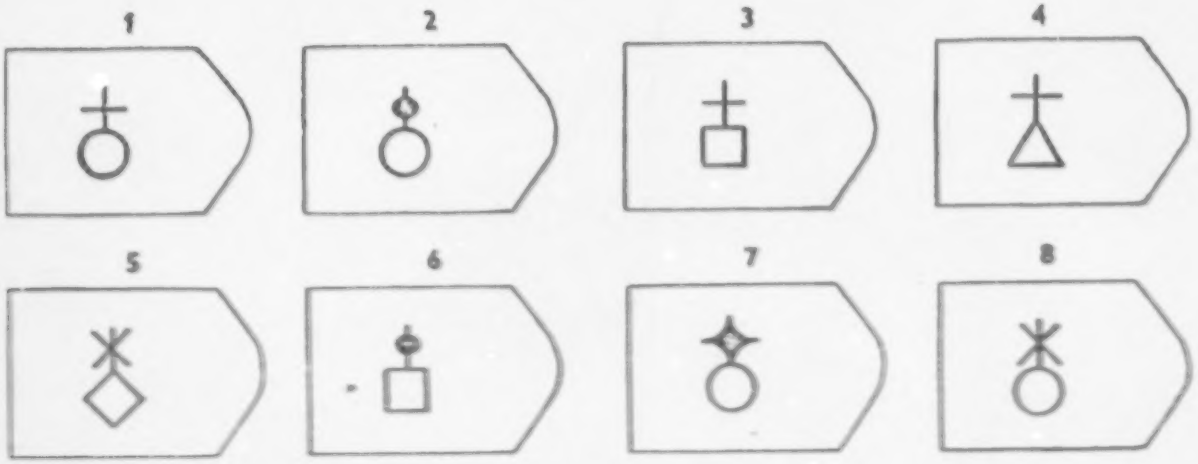

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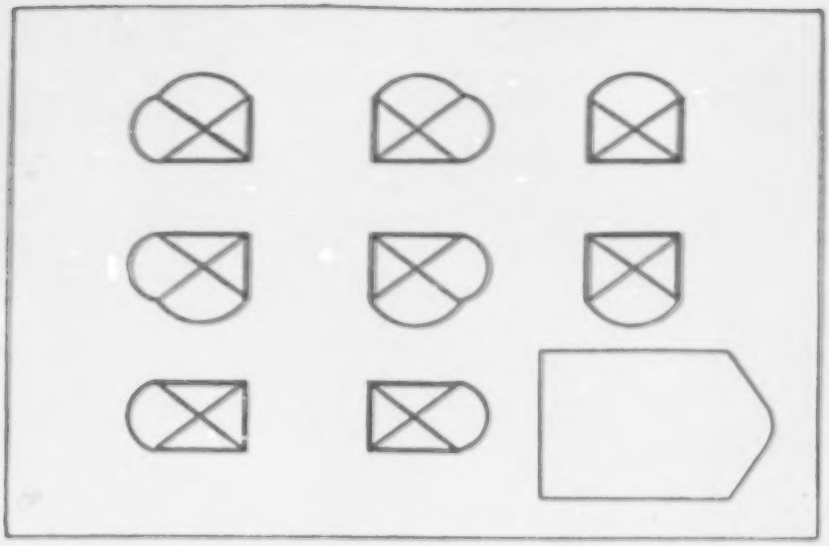

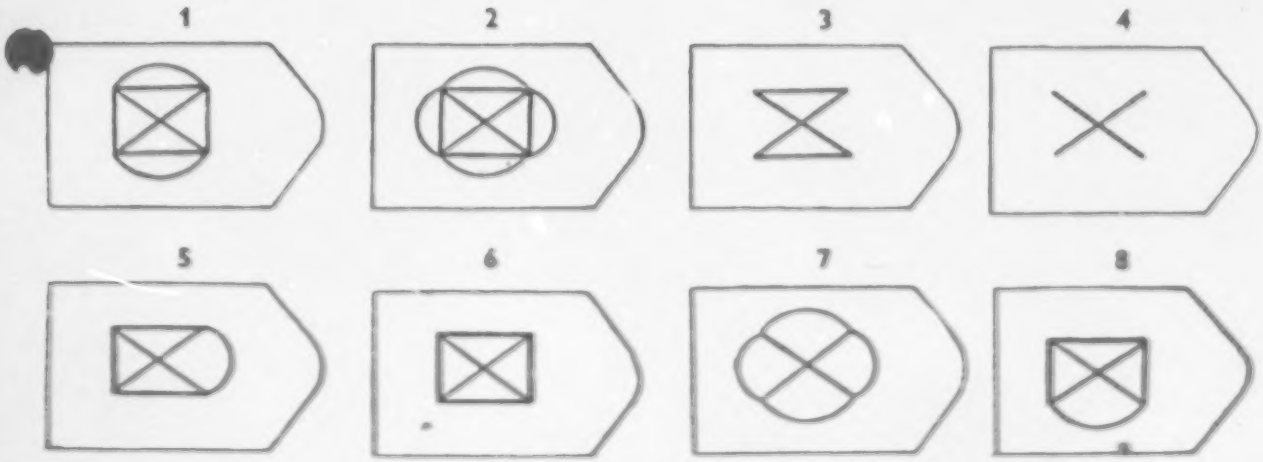

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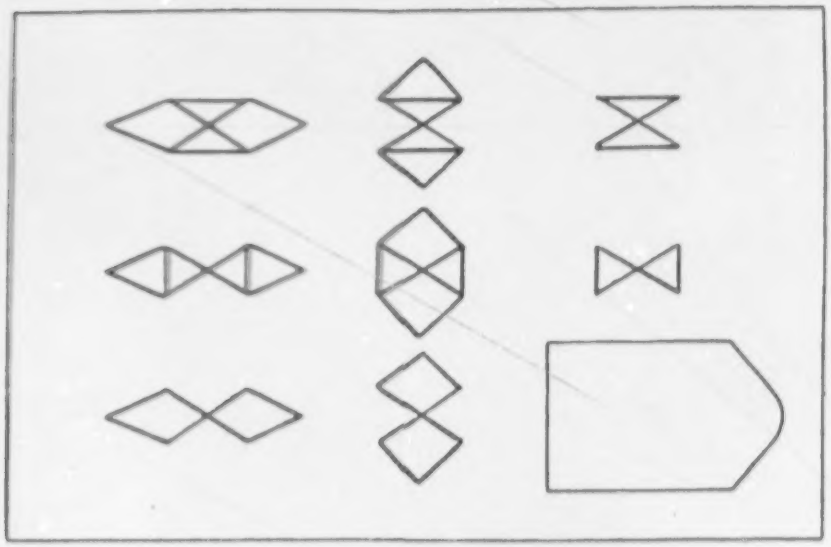

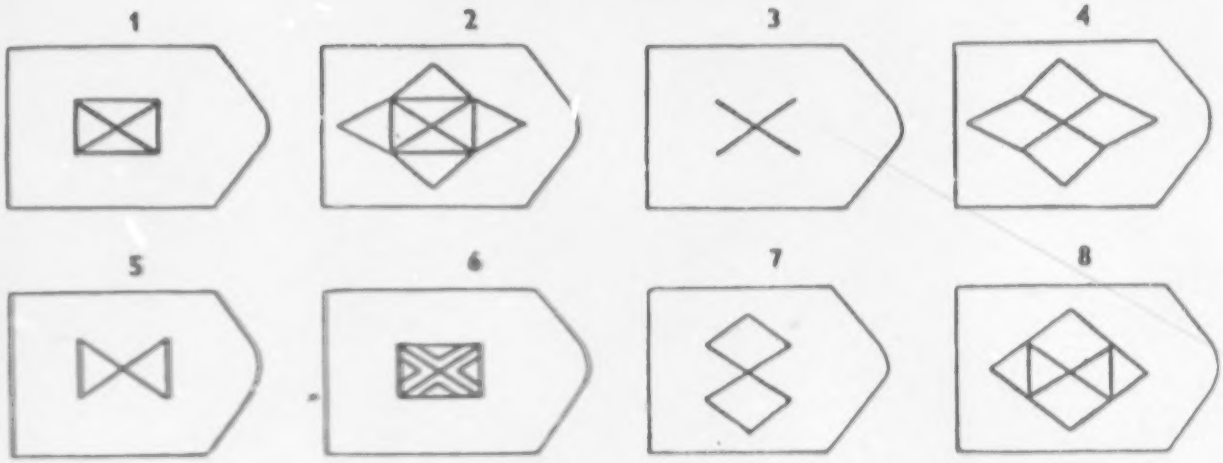

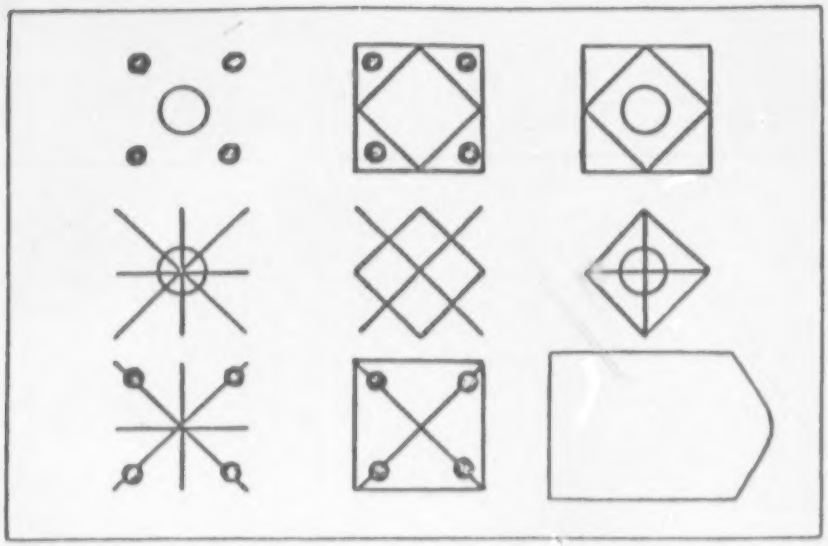

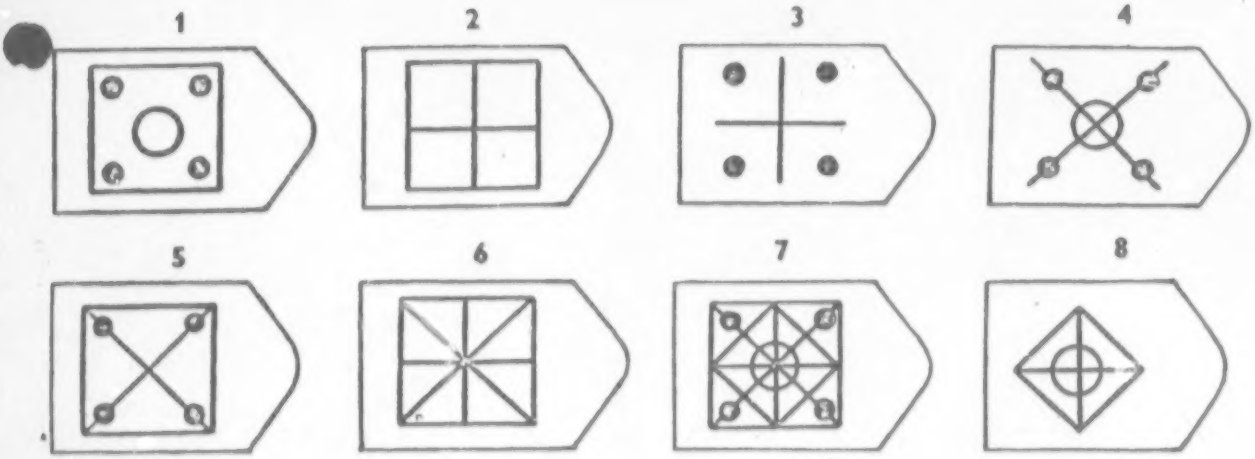
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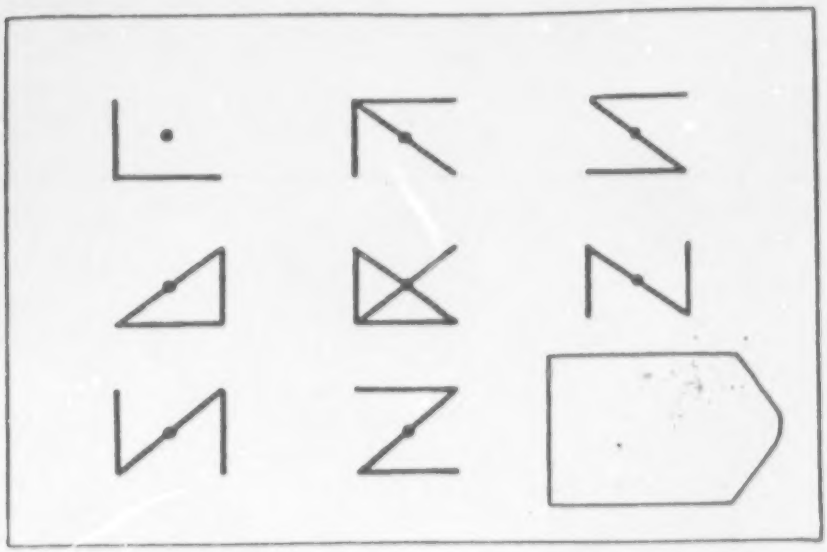

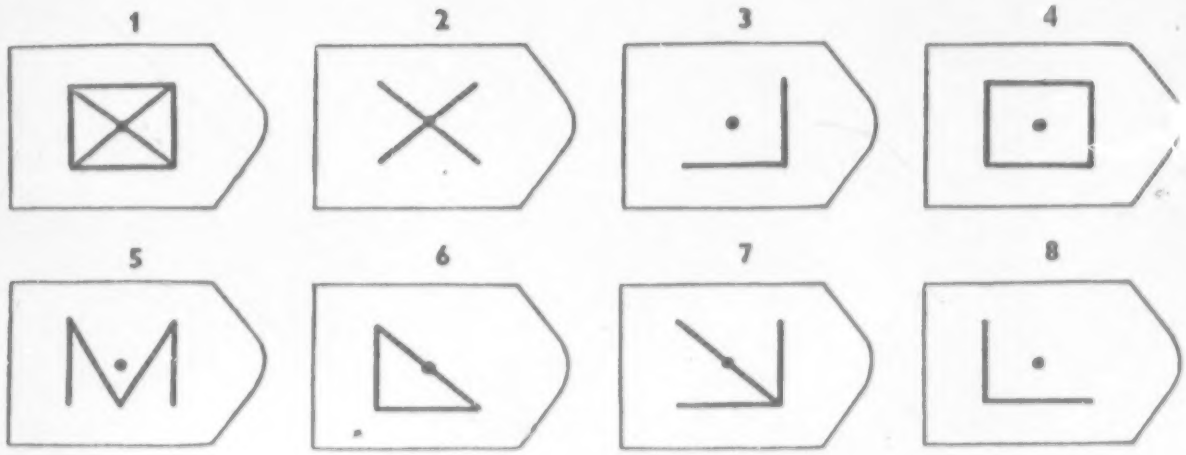
1
2
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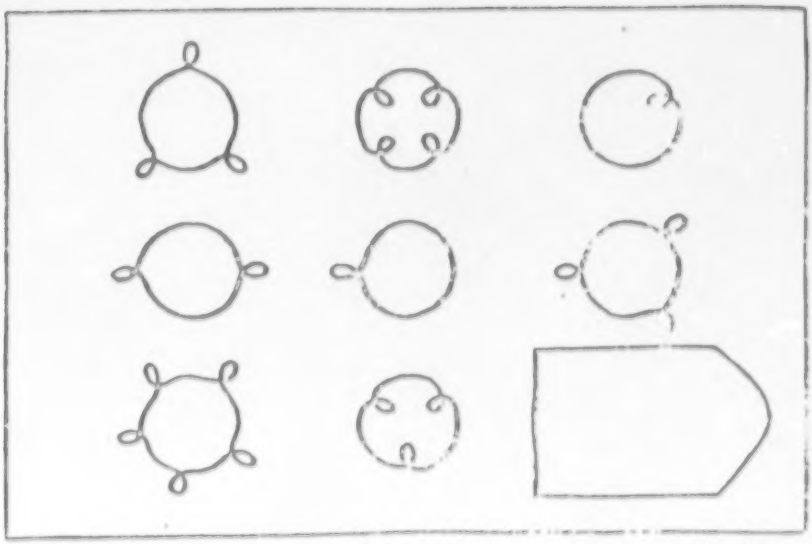
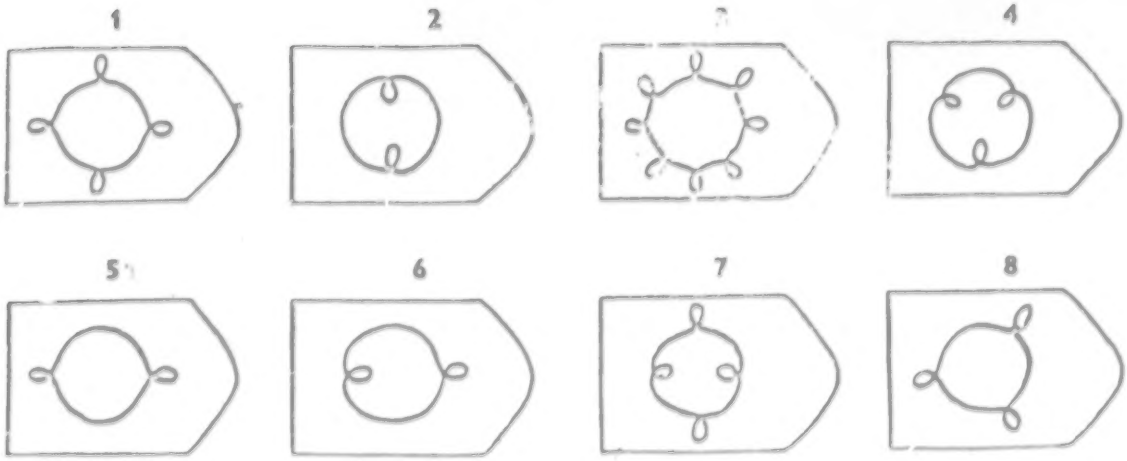
E 12





blue red yellow blue green red yellow green red yellow

blue green red blue yellow green yellow blue yellow red

green blue green red green yellow blue red blue yellow

blue red blue green red yellow red blue green yellow

red yellow red blue green blue green yellow blue yellow

red blue yellow red green blue yellow red blue yellow

green red yellow blue yellow green red yellow green blue

green blue red yellow green red green blue red yellow

blue yellow green yellow blue red blue green red blue

red blue green red blue green yellow red green yellow

green yellow green yellow blue red yellow green red blue

ans. key

red green

*** *****

Contrast Reactivity Test

---

stimulus projected on screen
(2 seconds)

---

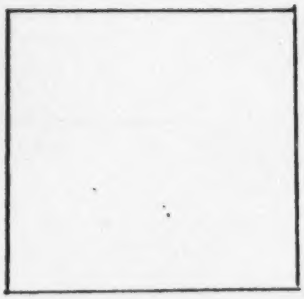
subjects response form
(response time = 6 seconds)

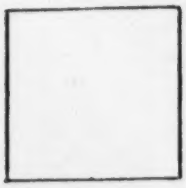
Subjects are shown 8 horizontal lines, varying in length, and asked to estimate the size of the line on the screen using their response form.

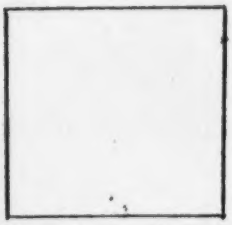
Schematizing Test of Leveling-Sharpening

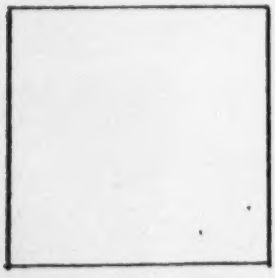
Stimulus
projected on screen

(actual size of image)









Subjects'
response form

1.
2.
3.
4.
5.

Subjects are shown a labeled 18 inch square and 1 inch square at the beginning of the test, followed by the 90 stimulus squares - each shown for 3 seconds with an 8 second response period. Subjects are asked to estimate the size of the square presented on the screen - in inches- using fractions or decimals if so desired.

Rod and Frame Apparatus

Seated subject views a rod within an encircling frame. Examiner rotates the surrounding frame and displaces rod from vertical. Subject's task is to rotate rod to vertical position. Scored in degrees displaced from vertical.

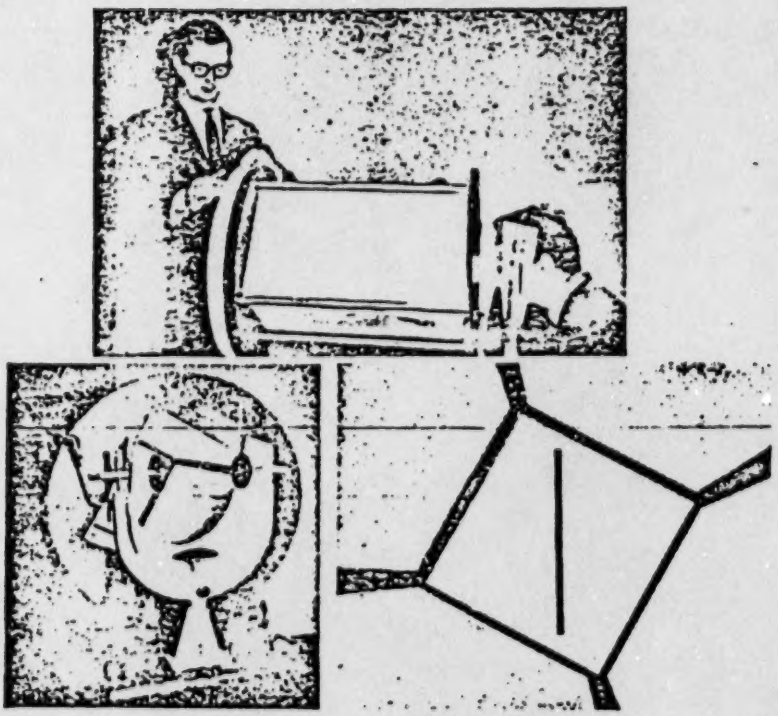


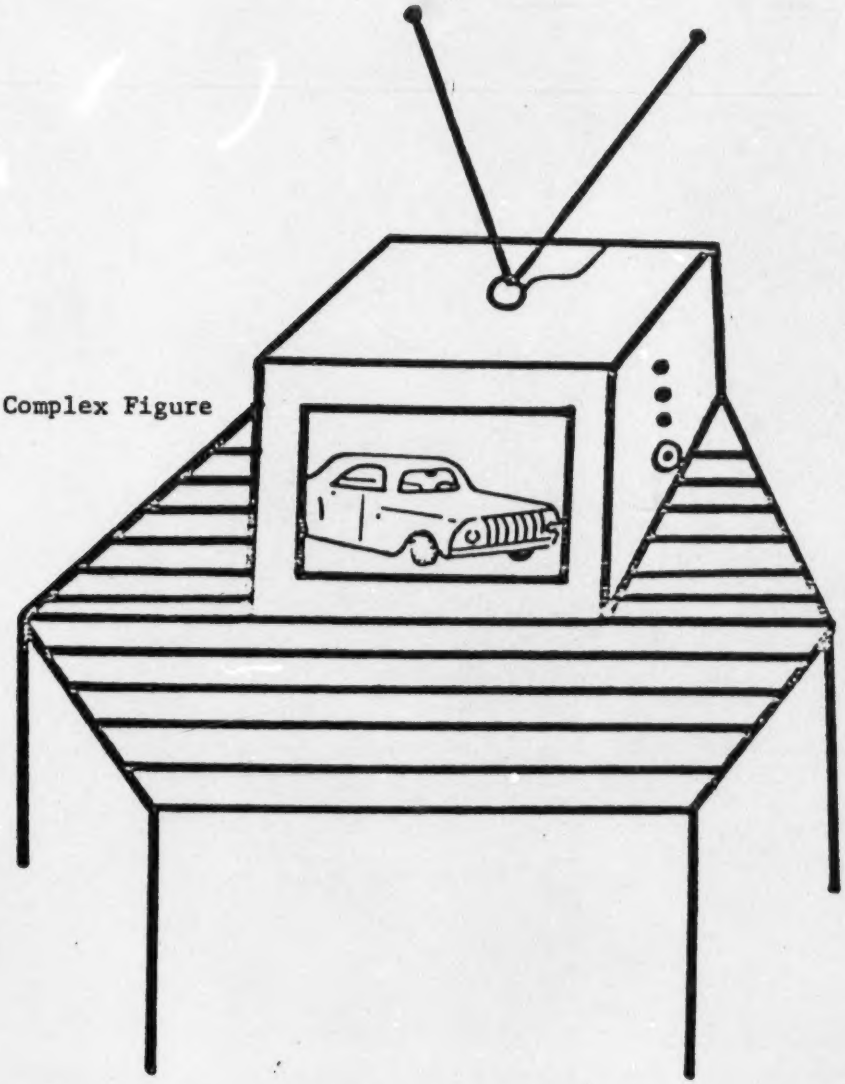
FIG. 1. Portable rod-and-frame apparatus: (Top) apparatus in use, (Left) end into which *S* looks, (Right) *S*'s view of the interior

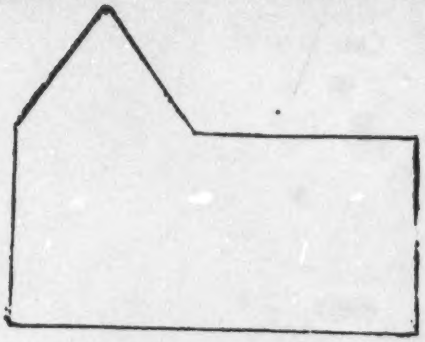
Simple Figure

T8

Task: Find the target figure ("simple figure") within the complex figure.

Complex Figure

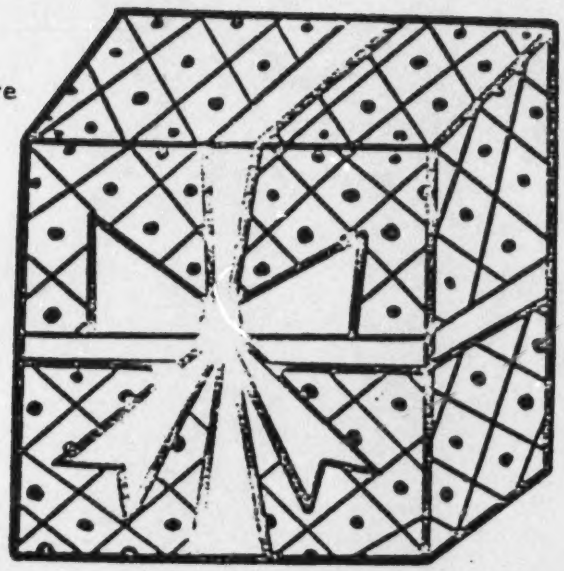




Simple Figure

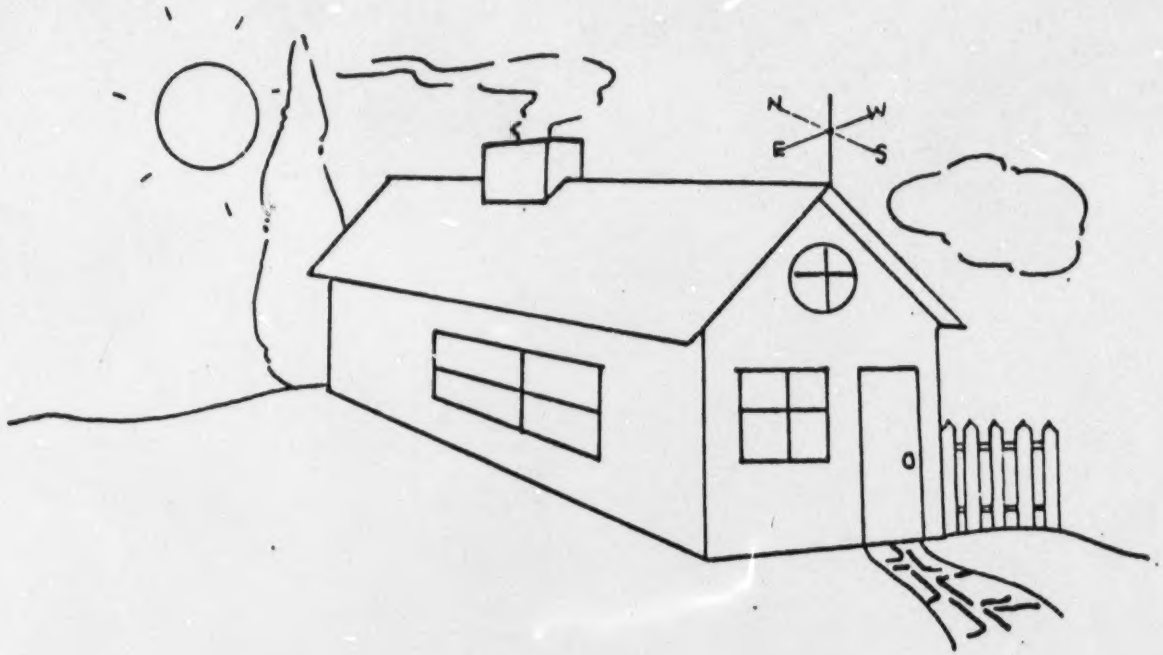
H_{11}

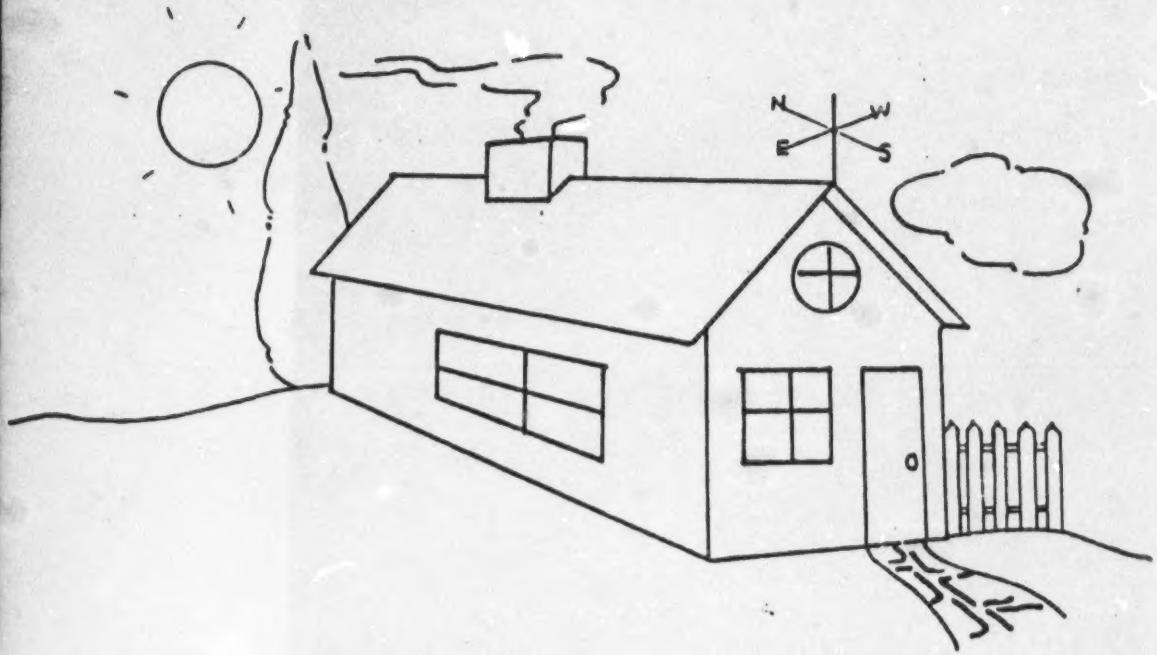
Complex Figure

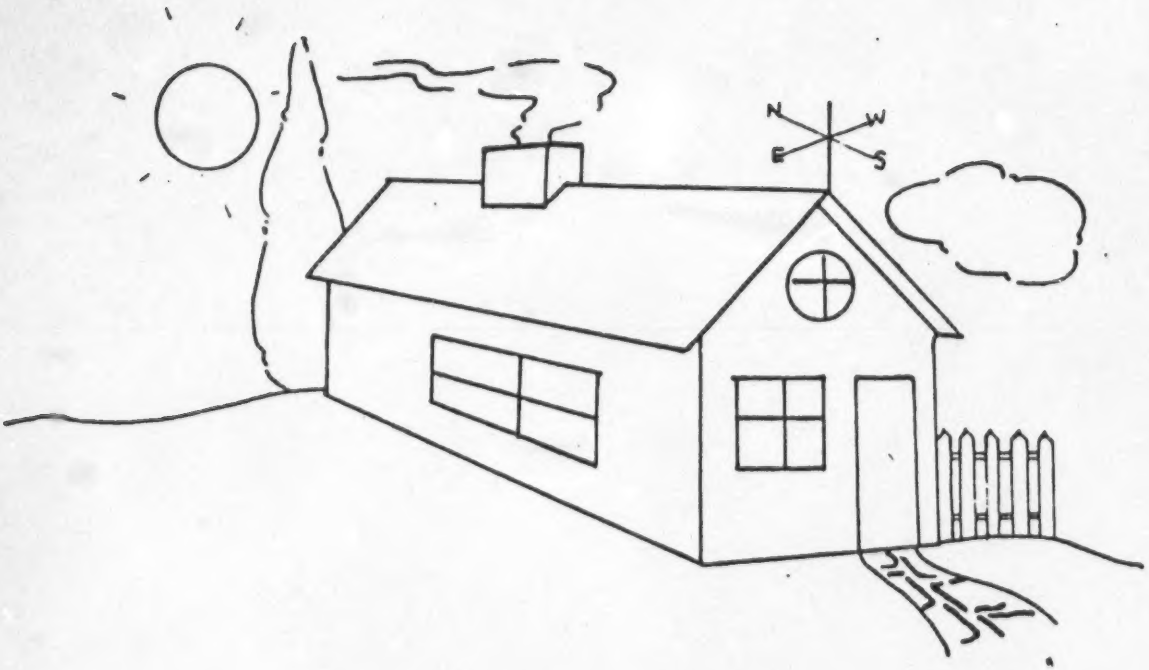


Leveling-Sharpening House Test

Series of line-drawings show progressive loss of line-drawing details. Drawings are shown serially and subject must detect change in drawing (drop-out of door knob, fence detail, drop-out of sun detail, etc.)




N
W
E
S


N
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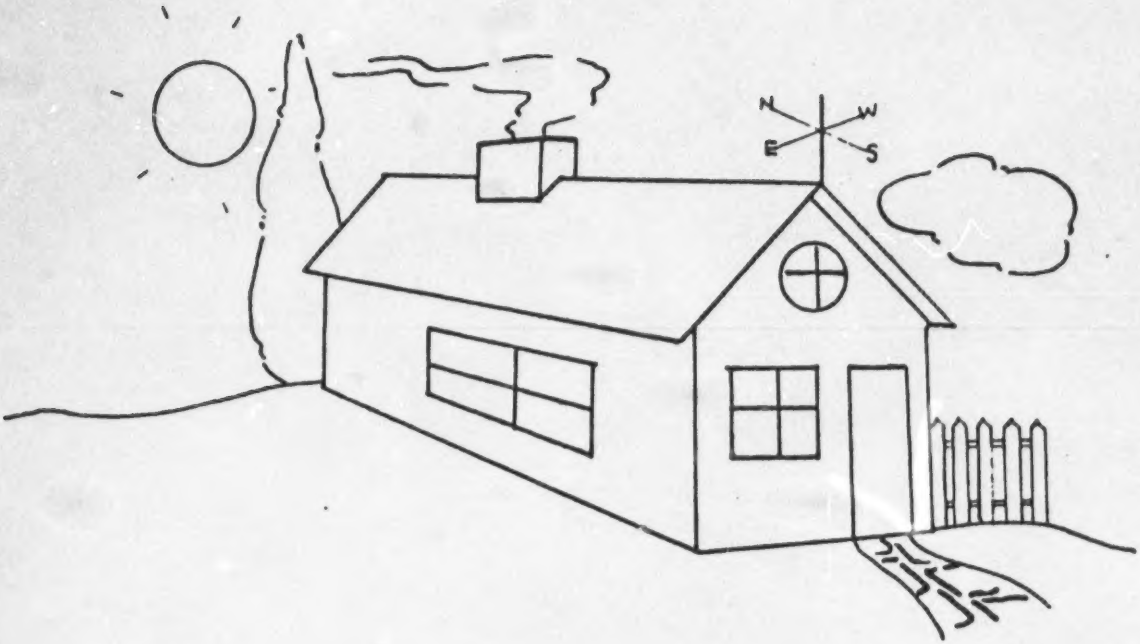
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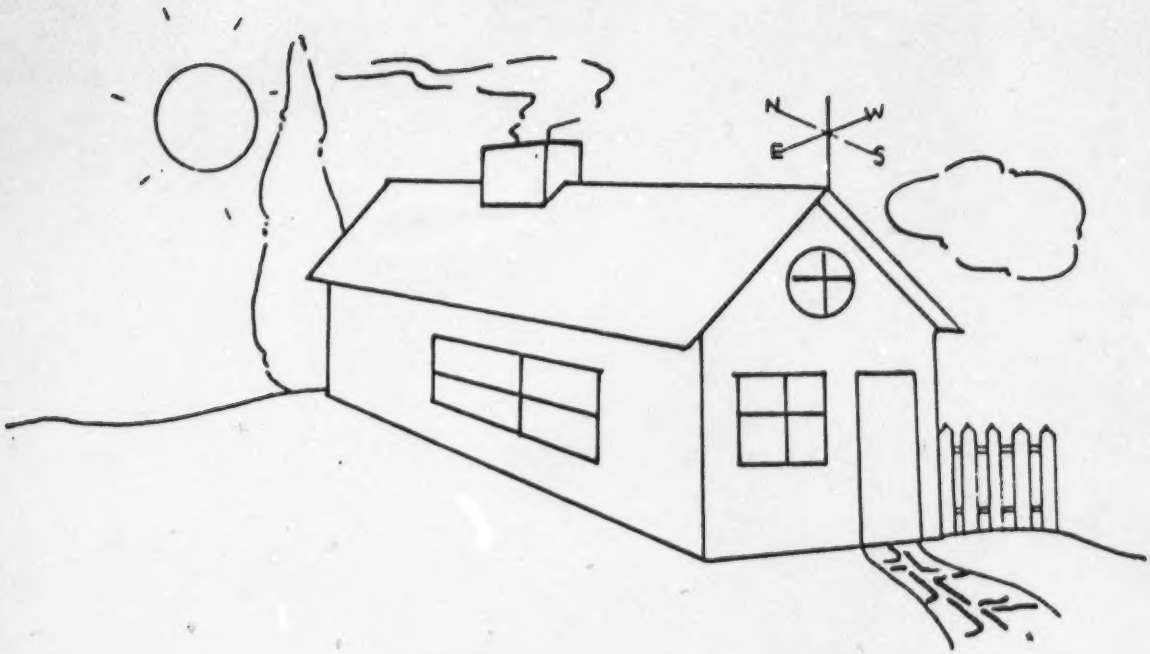
N
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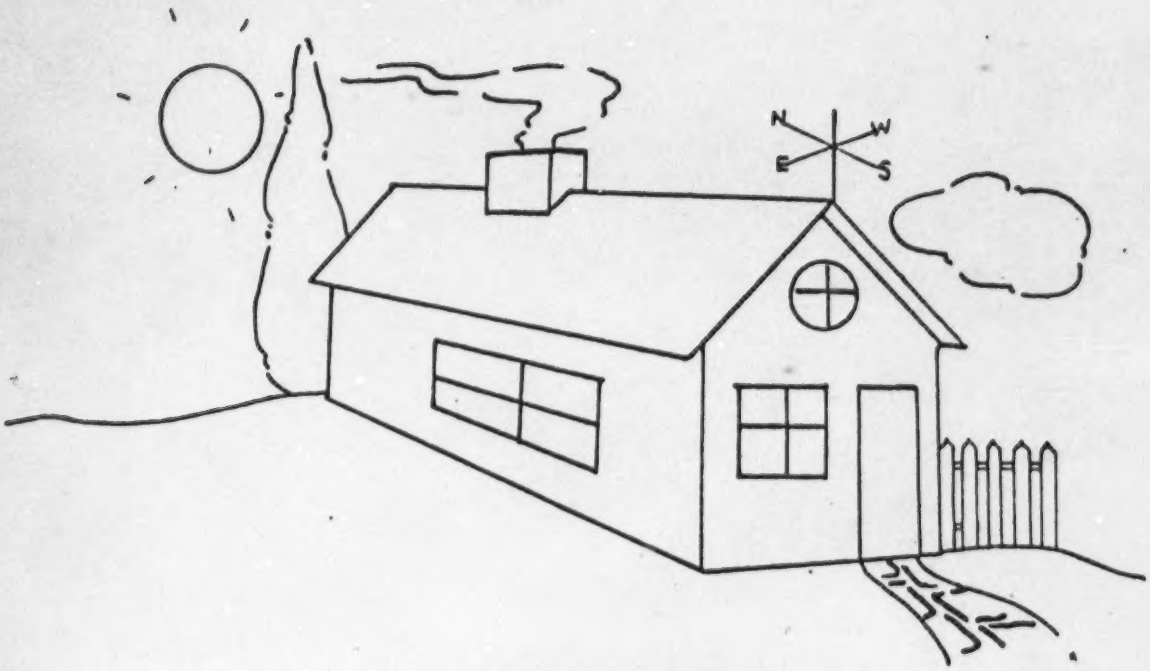
N
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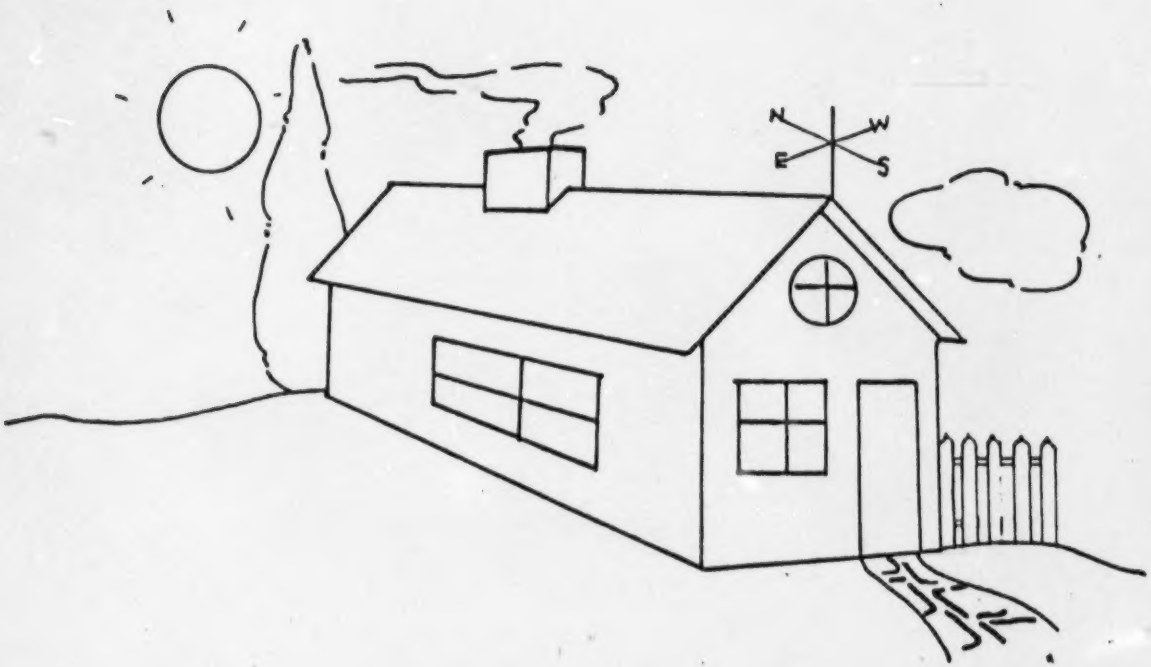
N
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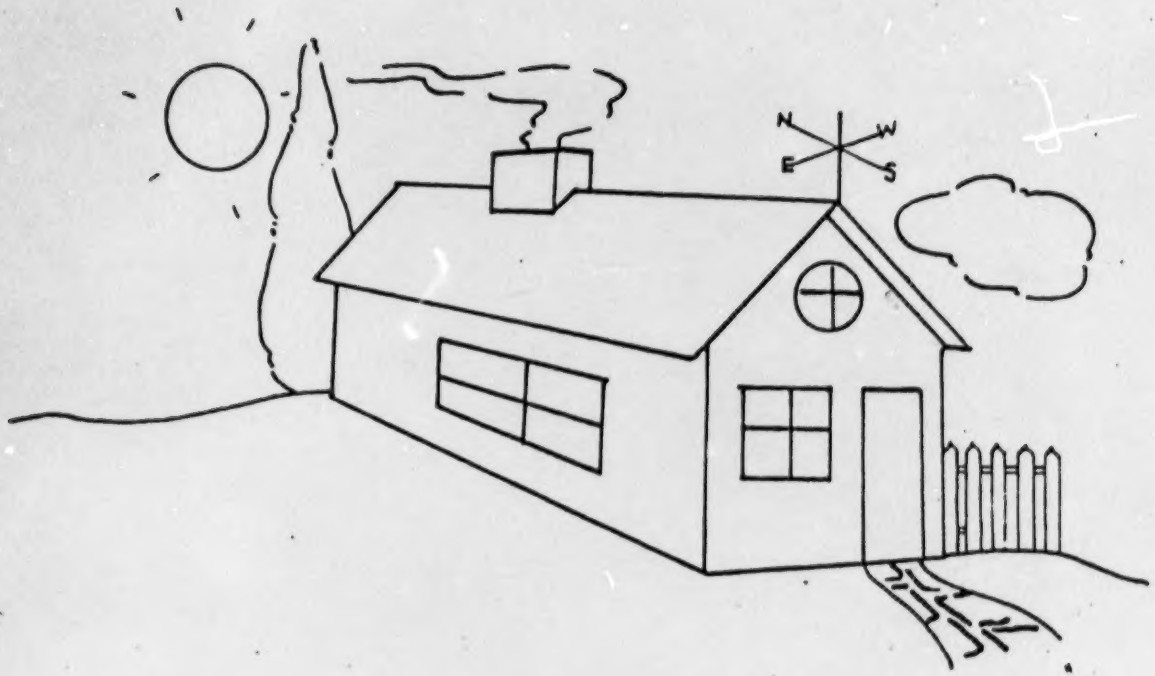
N
W
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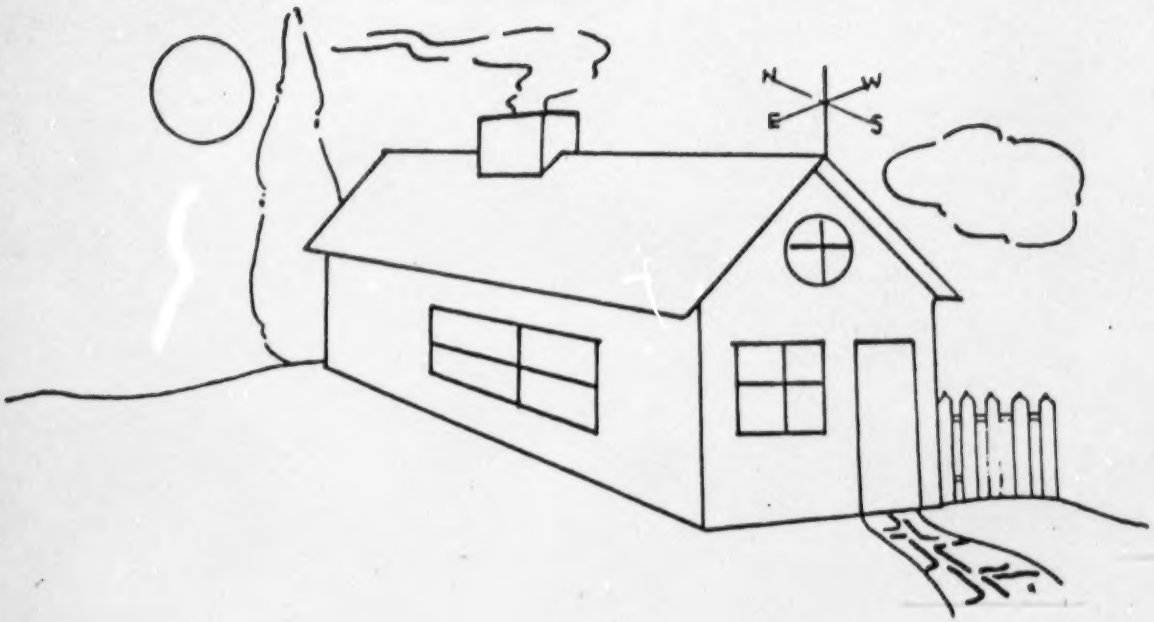

N
W
E
S

WORD BEGINNINGS AND ENDINGS

Instructions

This is a test of your ability to think of as many words as you can that begin with one letter and end with another.

The following words all start with S and end with N.

sun
spoon
stain
sin

Try to think of some more English words that start with S and end with N. Names of people or places do not count.

_____	_____
_____	_____
_____	_____
_____	_____

For the two parts of the test you will be given different first and last letters.

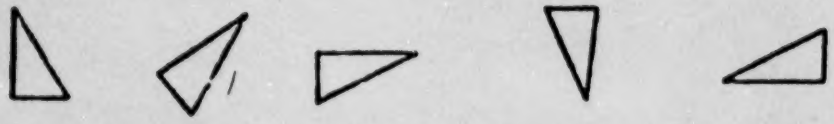
You will have 3 minutes for each part.

Do not go to Part 2 until you are asked to do so.

PLEASE DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

CARD ROTATIONS

This is a test of your ability to see differences between figures. Look at the 5 figures below.



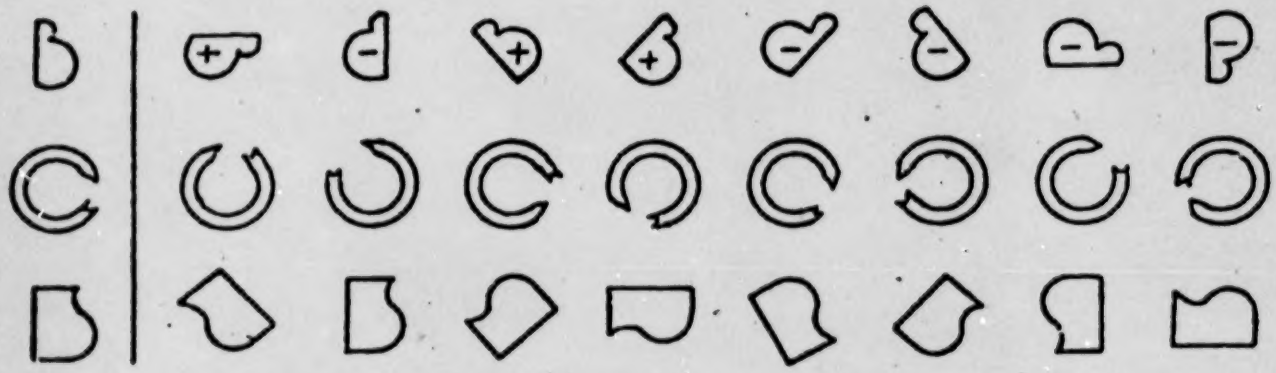
All of these drawings are of the same figure which has been slid around on the page into different positions.

Now look at the next 2 figures:

These two are not completely alike. You cannot slide the first around on the page so that it would cover the second. It would have to be flipped over, so that the other side would show.

Each problem in this test consists of a figure on the left of a line and 8 figures on the right. You are to decide whether each of the 8 cards on the right shows the same side of the figure or the opposite side. Put a plus (+) on each figure that shows the same side and a minus (-) if it shows the opposite side.

Practice on the following rows. The first row has already been marked. Try the next two rows.

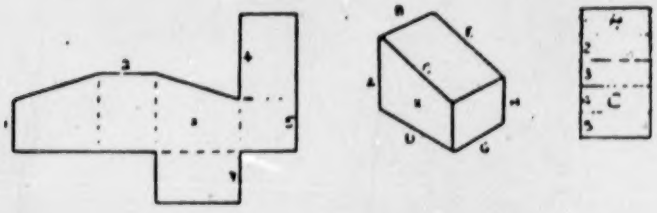


Do not guess because your mistakes will be subtracted from your score.

You will have 3 minutes for each of the 2 pages of this test. Do not go to page 2 until asked to do so.

PLEASE DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Surface Development Test, 2 parts, 6 items per part, 5 questions per item. In this test the subject has to imagine or visualize how a piece of paper can be folded to form some object. Two drawings are presented such as those shown below. The drawing on the left is a pattern which can be folded on the dotted lines to form the object on the right. The subject has to figure out which of the lettered edges on the object are the same as the numbered edges on the pattern at the left, and identify the letters of the answers in the numbered spaces at the far right. He is told that the side of



the pattern marked with the X will always be the same as the side of the object with the X. Therefore, the paper must always be folded so that the X will be on the outside of the object.

N E W I R T

H U T R T

E O T S R T

E T O M N M

R C H H C U

L I A N A M

L V A Y E L

B U R L E T O

HANDEDNESS QUESTIONNAIRE

Name: _____ Sex: _____

1.	Which hand do you write with:	right	left	either
2.	Which eye would you use for a microscope or telescope:	right	left	either
3.	Which hand do you use in combing your hair:	right	left	either
4.	Which hand do you use to put the house key in the lock:	right	left	either
5.	When you hold a broom to sweep the floor, which hand is on top:	right	left	either
6.	When you swing a baseball bat or golf club, which hand is nearer the end that you hold:	right	left	either
7.	When you thread a needle, which hand holds the needle:	right	left	either
8.	When you fold your hands as in prayer, which thumb is on top:	right	left	either
9.	When you fold your arms, which hand is on top resting on your other arm:	right	left	either
10.	Which side do you sleep on, most of the time:	right	left	either
11.	When jumping, as over a creek, which foot touches the ground last:	right	left	either
12.	When sighting over a gun, which eye do you close:	right	left	either
13.	Which hand holds the match, when you strike the match:	right	left	either
14.	Which hand holds the knife when you peel a potato or apple:	right	left	either
15.	Have you ever found it necessary to change from one hand to the other due to illness, injury, or <u>social pressure</u>? YES NO If answer is YES, please give details below.			
16.	Which hand do you use to deal cards?	right	left	either
17.	With which foot do you kick a ball?	right	left	either
18.	Which foot do you prefer to hop on?	right	left	either